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# TECHNICAL SUPPORT
# HYDROCARBON/PHOTOCHEMICAL OXIDANT CONTROL STRATEGY FOR THE STATE OF TEXAS

ENVIRONMENTAL PROTECTION AGENCY

JANUARY 1976

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# TECHNICAL SUPPORT DOCUMENT

# HYDROCARBON/PHOTOCHEMICAL OXIDANT CONTROL STRATEGY
FOR
THE STATE OF TEXAS

JANUARY 1976

ENVIRONMENTAL PROTECTION AGENCY
REGION VI
1600 PATTERSON STREET, DALLAS, TEXAS 75201

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This report presents the results of a reevaluation of the Texas Photochemical Oxidant Control Plan and recommends specific control strategies for each Texas area which exceeds the oxidant standard. The purpose of the reevaluation was to resolve technical questions that had arisen on the original November 1973 EPA plan as a result of litigation. The reevaluation was a joint effort of the Environmental Protection Agency, Region VI and the Texas Air Control Board.

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## TABLE OF CONTENTS

Page

1.0 BACKGROUND . . . . . . . . . . . . . . . . . . . . .1-1

2.0 SUMMARY . . . . . . . . . . . . . . . . . . . . . . 2-1

3.0 AIR QUALITY DATA . . . . . . . . . . . . . . . . . .3-1

3.1 Data Validation . . . . . . . . . . . . . . . . .3-1
3.2 Statistical Analysis . . . . . . . . . . . . . . 3-11
3.3 Meteorological Analysis . . . . . . . . . . . . .3-49

4.0 HYDROCARBON/PHOTOCHEMICAL OXIDANT MODEL . . . . . . 4-1

4.1 Available Models . . . . . . . . . . . . . . . . 4-1
4.2 Limitations of Linear Rollback Model . . . . . 4-6
4.3 Texas Modeling Areas . . . . . . . . . . . . . . 4-9
4.4 Emission Reduction Required . . . . . . . . . . .4-19

5.0 DEVELOPMENT OF REACTIVE HYDROCARBON EMISSION INVENTORIES FOR TEXAS . . . . . . . . . . . . . . . . 5-1

5.1 Introduction . . . . . . . . . . . . . . . . . . 5-1
5.2 Photochemical Reactivity . . . . . . . . . . . . 5-3
5.3 Stationary Source Inventory Development . . . .5-9
5.4 Mobile Sources . . . . . . . . . . . . . . . . . 5-23
5.5 Ciudad Juarez Emission Estimate . . . . . . . .5-26
5.6 Emission Inventory Summaries . . . . . . . . . . 5-28

6.0 CONTROL MEASURES CONSIDERED . . . . . . . . . . . . 6-1

6.1 Existing Controls . . . . . . . . . . . . . . . .6-1
6.2 Extension of Texas Regulation V . . . . . . . .6-1
6.3 Gasoline Marketing Vapor Recovery . . . . . . .6-3
6.4 Control of Emissions from Crude Petroleum . . .6-10
6.5 Ship and Barge Vapor Recovery . . . . . . . . .6-11
6.6 Solvent Control (Degreasing) . . . . . . . . . . 6-12
6.7 Inspection-Maintenance of Light Duty Vehicles .6-13
6.8 VMT Reduction Measures . . . . . . . . . . . . . 6-15

7.0 RECOMMENDED CONTROL MEASURES . . . . . . . . . . . 7-1

7.1 Austin Area Recommended Controls . . . . . . . .7-5
7.2 Beaumont/Port Arthur Area Recommended Controls . . . . . . . . . . . . . . . . . . . .7-16

Page

7.3 Corpus Christi Recommended Controls . . . . . 7-18
7.4 Dallas/Fort Worth Recommended Controls . . . .7-21
7.5 El Paso Area Recommended Controls . . . . . . 7-24
7.6 Houston/Galveston Area Recommended Controls . 7-26
7.7 San Antonio Area Recommended Controls . . . . 7-28
7.8 Cost Effectiveness of Recommended Control Measures . . . . . . . . . . . . . . . . . . . .7-32

APPENDICES

# LIST OF TABLES

Page

1-1 Air Quality Control Regions Exceeding the Photochemical Oxidant . . . . . . . . . . . . . . . . . 1-3

3-1 Ozone Levels Used in the Oxidant Control Plan . . . 3-2

3-2 Monitoring Stations for Oxidants State of Texas . . . . . . . . . . . . . . . . . . 3-13

3-3 Extent of Violations . . . . . . . . . . . . . . . . . . 3-15

3-4 thru 3-16 Summary of Data . . . . . . . . . . . . . . . . . . . . . . . . . 3-18 thru 3-30

3-17 thru 3-25 Table of Model Estimators Highest and Second Highest Concentrations Observed vs Estimated . . . . . . . . . 3-37 thru 3-45

3-26 Mean and Standard Deviation of Predicted Minus Observed Values . . . . . . . . . . . . . . . . . . . 3-47

4-1 Hydrocarbon Reduction Requirements . . . . . . . . 4-20

5-1 Non-Reactive Carbon Compounds . . . . . . . . . . . 5-5

5-2 Weight Percentage Factors for Refinery In-Process and Product Streams . . . . . . . . . . . . . . . . . 5-6

5-3 Mobile Source Reactivity Factors . . . . . . . . . .5-9

5-4 Ship and Barge Reactive Hydrocarbon Emissions . . . 5-20

5-5 Reactive Hydrocarbon Emission Inventory for Austin Area . . . . . . . . . . . . . . . . . . . . . 5-30

5-6 Reactive Hydrocarbon Emission Inventory for Beaumont/Port Arthur Area . . . . . . . . . . . . . 5-31

5-7 Reactive Hydrocarbon Emission Inventory for Corpus Christi Area . . . . . . . . . . . . . . . . . 5-32

5-8 Reactive Hydrocarbon Emission Inventory for Dallas/Fort Worth Area . . . . . . . . . . . . . . . 5-33

Page

5-9 Reactive Hydrocarbon Emission Inventory for El Paso Area (Juarez Not Included) . . . . . . . . . 5-34

5-10 Reactive Hydrocarbon Emission Inventory for El Paso Area (Juarex Included) . . . . . . . . . . . 5-35

5-11 Reactive Hydrocarbon Emission Inventory Estimate in Juarez . . . . . . . . . . . . . . . . . 5-36

5-12 Reactive Hydrocarbon Emission Inventory for Houston/Galveston Area . . . . . . . . . . . . . . . 5-37

5-13 Reactive Hydrocarbon Emission Inventory for San Antonio Area . . . . . . . . . . . . . . . . . . 5-38

6-1 Reactive Hydrocarbon Emission Reduction in 1977 with Possible Control Measures . . . . . . . . . . 6-6

6-2 Reactive Hydrocarbon Emission Reduction in 1980 with Possible Control Measures . . . . . . . . . . 6-7

6-3 Reactive Hydrocarbon Emission Reduction in 1985 with Possible Control Measures . . . . . . . . . . 6-8

6-4 Employment Data by Size of Facility Manufacturing . . . . . . . . . . . . . . . . . . . . . .6-20

6-5 Employment Data by Size of Facility Commercial . . . . . . . . . . . . . . . . . . . . 6-22

6-6 Employment Data by Size of Facility Transportation . . . . . . . . . . . . . . . . . . . 6-24

6-7 Student and Faculty Population at Educational Facilities . . . . . . . . . . . . . . . . . . . . . 6-26

7-1A Recommended Additional Controls for Texas Long Range Oxidant Plan . . . . . . . . . . . . . . . . . 7-3

7-1B Recommended Additional Controls for Texas Interim Oxidant Plan . . . . . . . . . . . . . . . . . . . . 7-4

7-2A Reactive Hydrocarbon Emission Reductions under Recommended Long Range Stategy for Austin Area . . 7-13

7-2B Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for Austin Area . . . 7-15

Page

7-3A Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Beaumont/Port Arthur Area . . . . . . . . . . . . . . . . . . 7-17

7-3B Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for Beaumont/Port Arthur Area . . . . . . . . . . . . . . . . . . . 7-19

7-4A Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Corpus Christi . 7-20

7-4B Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for Corpus Christi . . 7-22

7-5 Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Dallas/Fort Worth Area . . . . . . . . . . . . . . . . . 7-23

7-6A Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for El Paso (Juarez Included) . . . . . . . . . . . . . . . . 7-25

7-6B Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for El Paso Area (Juarez Included) . . . . . . . . . . . . . . . . 7-27

7-7 Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Houston/Galveston Area . . . . . . . . . . . . . . . . . 7-29

7-8A Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for San Antonio Area . . . . . . . . . . . . . . . . . . . . . 7-30

7-8B Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for San Antonio Area . . . . . . . . . . . . . . . . . . . . . 7-31

7-9A Cost Estimates for Recommended Long Range Controls . . . . . . . . . . . . . . . . . . . . 7-33

7-9B Cost Estimates for Recommended Interim Controls . 7-34

7-10 Annualized Costs for Long Range Control Measures in Texas . . . . . . . . . . . . . . . 7-35

7-11 Gaslone Dispensing Facility Ownership . . . . . 7-38

## LIST OF FIGURES

Page

3-1 Availability of Data . . . . . . . . . . . . . . . . . 3-14

3-2 1-F(x) vs Concentration . . . . . . . . . . . . . . . . .3-35

4-1 Priority I Regions For Oxidants . . . . . . . . . . . .4-10

4-2 Model Area AQCR 212 (Austin Area) . . . . . . . . . .4-12

4-3 Model Area AQCR 106 (Beaumont/Port Arthur Area) . . .4-13

4-4 Model Area AQCR 214 (Corpus Christi Area) . . . . . .4-14

4-5 Model Area AQCR 215 (Dallas/Fort Worth Area) . . . . 4-15

4-6 Model Area AQCR 153 (El Paso Area) . . . . . . . . . 4-16

4-7 Model Area AQCR 216 (Houston/Galveston Area) . . . . 4-17

4-8 Model Area AQCR 217 (San Antonio Area) . . . . . . . 4-18

7-1 Oxidant Levels 1973 - 1985 (Austin) . . . . . . . . .7-6

7-2 Oxidant Levels 1973 - 1985 (Beaumont/Port Arthur) . .7-7

7-3 Oxidant Levels 1971 - 1985 (Corpus Christi) . . . . .7-8

7-4 Oxidant Levels 1974 - 1985 (Dallas/Fort Worth) . . . 7-9

7-5 Oxidant Levels 1974 - 1985 (El Paso) . . . . . . . . 7-10

7-6 Oxidant Levels 1974 - 1985 (Houston/Galveston) . . . 7-11

7-7 Oxidant Levels 1971 - 1985 (San Antonio) . . . . . . 7-12

# LIST OF APPENDICES

Appendix A - Statistical Analysis Calculations and Figures.

Appendix B - Sample Texas Air Control Board Inventory Questionnaire.

Appendix C - Texas Air Control Board (TACB) Supplemental Questionnaire.

Appendix D - TACB Worksheets and Data on Stationary Source Hydrocarbon Breakdowns.

Appendix E - TACB Inventory Worksheets by Region and Industry for Stationary Sources.

Appendix F - Exxon Ship and Barge Emission Factor Data.

Appendix G - TACB Inventory Worksheets by Region for Mobile Sources.

Appendix H - TACB Degreasing Inventory Worksheets.

Appendix I - TACB Description of Motor Vehicle Emission Calculations.

Appendix J - TACB Emission Reduction Worksheet.

# 1.0 BACKGROUND

On April 15, 1973, the State of Texas submitted a plan to the Environmental Protection Agency (EPA) for control of hydrocarbon emissions and attainment of the national ambient air quality standard (NAAQS) for photochemical oxidants. The plan was disapproved by the Administrator because it did not provide for the degree of control necessary for attainment of the national standard. Subsequently, as required by the Clean Air Act, on July 31, 1973, EPA proposed a plan for attainment of the photochemical oxidant standard in Texas and held public hearings on the plan. The final plan was promulgated on November 6, 1973. Shortly thereafter, the State of Texas, Harris County, and 23 other litigants filed petitions requesting review of the regulations promulgated by the EPA on November 6.

The U.S. Court of Appeals for the Fifth Circuit rendered its decision on August 7, 1974. The Court held that the Environmental Protection Agency determined in a legal and enforceable manner that the State's plan was inadequate. It further held that certain of the regulations were valid and enforceable, and that certain of the Agency's regulations were either invalid or must be deferred for further Agency considerations.

In September of 1974 the EPA and the Texas Air Control Board (TACB) entered into a joint study to reevaluate certain aspects of the plan. At the request of the TACB, the EPA agreed to a restudy of the entire data base, instead of just those parts of the control strategy remanded by the Court for restudy. As a result, the EPA did not immediately initiate enforcement actions on those portions of the plan held valid and enforceable by the Court.

The TACB study was completed in March of 1975 and was published in a report entitled, "Reactive Carbon Compound Control Strategy Reexamination for the State of Texas (Ref. 1-1)." Updated ambient air quality data and hydrocarbon emission data were used and published in this report.

On March 4, 1975, staff members of the Dallas Regional Office of the EPA met with the Chairman and staff of the TACB to discuss the findings. At this meeting the EPA stated that the EPA was in substantial agreement with the air quality and emission data base used by the TACB staff in their restudy. This was a significant point since there had not been agreement on the original emission data base, one of the major points of the litigation.

The restudy not only confirmed the original EPA study (Ref. 1-2) but showed a worsening of the air quality in all seven areas of the State included in the original study. The restudy showed that the air quality had either deteriorated in some areas or had not improved as anticipated, that the photochemical oxidant standard was being violated in all seven Texas areas covered in the November 6, 1973 promulgation, and that the projections did not show attainment of the photochemical oxidant standards by mid-1977 in any of these areas.

The technical analysis developed in this report is in support of hydrocarbon/photochemical oxidant control strategies recommended for counties in each of the air quality control regions (AQCRs) listed in Table 1-1.

Table 1-1 --Air quality control regions exceeding the photochemical oxidant standard

| Region | 40 CFR Section | Federal designation | State designation |
|---|---|---|---|
| Austin-Waco | 81.134 | 212 | 3 |
| Corpus Christi-Victoria | 81.136 | 214 | 5 |
| Dallas-Fort Worth | 81.39 | 215 | 8 |
| El Paso-Las Cruces-Alamogordo (Texas Section) | 81.82 | 153 | 11 |
| Houston-Galveston | 81.38 | 216 | 7 |
| San Antonio | 81.40 | 217 | 9 |
| Southern Louisiana-Southeast Texas (Texas Portion) | 81.53 | 106 | 10 |

## Section 1 References

1-1 TACB Report "Reactive Carbon Compound Control Strategy Reexamination For the State of Texas," Special Project Report No. SP-1, March 13, 1975.

1-2 EPA Region VI Report "Background and Support Document For Texas Photochemical Oxidant Control Strategy 1973".

# 2.0 SUMMARY

This report presents the results of a reevaluation of the Texas Photochemical Oxidant Control Plan and recommends specific control strategies for each Texas area which exceeds the oxidant standard. Sections 3.0, 4.0, and 5.0 present the methodology used by the EPA and the TACB in the reevaluation of air quality and emissions data. Section 6.0 and 7.0 present the possible and recommended strategies. Several appendices are also included which include much of the detailed-supplemental information developed or used during the reevaluation effort.

Sections 3.0 through 7.0 are summarized as follows:

Section 3.0: This section presents the evaluation of Texas oxidant air quality data. The results of quality assurance checks as well as a statistical analyses of the data are presented. From these evaluations the air quality data used as a basis for control strategy development are shown to be valid and representative of oxidant levels in Texas.

Section 4.0: This section discusses the various oxidant modeling techniques for relating emissions of photochemical oxidant precursors and expected air quality. As in the previous control plan, EPA concludes that although there are uncertainties and limitations, the linear rollback model is still the best modeling technique available. Explanations of the linear rollback limitations as well as the details of how this model was applied in Texas are presented.

Section 5.0: In this section the details of the reactive hydrocarbon emission inventory reevaluation are presented. Using the linear rollback model, the projected emission inventory shows that additional reductions beyond the reductions from existing stationary source regulations and the Federal Motor Vehicle Control Program will be required.

Section 6.0: Possible additional controls are described in detail in this section. Expected emission reductions for each of the emission controls in each of the seven problem areas for the years 1977, 1980, and 1985 are presented.

Section 7.0: This section presents the recommended controls for each area along with the predicted effects of the strategy on air quality. Although none of the areas are expected to attain the standard, the additional control measures will provide substantial reductions in emissions and improved air quality. The rationale for the measures recommended along with their expected costs are also included.

# 3.0 AIR QUALITY DATA

The reduction model for developing a control strategy for each of the seven air quality control regions (AQCRs) under study depends on the second highest ozone measurement for the year requiring the greatest percent of emission reductions (beyond that provided by the existing stationary and mobile source controls) for attainment of the photochemical oxidant standard by mid-1977. Data is available for these seven AQCRs from 1971 to 1974 (not continuously in all cases). This year from which reductions in hydrocarbon emissions are required is termed the baseline year.

Since the reduction model is dependent on a single air quality measurement for each region it is necessary to determine (1) the validity of the value, and (2) how representative that value is of a long-term second high, i.e., is the chosen value representative or an anomaly. To answer the first question, an extensive data validation effort was conducted. The second question is answered by performing a statistical and meteorological analysis on the available body of data.

## 3.1 Data Validation

### Introduction

The seven high and seven second high ozone values, which are the basis of the oxidant control plan, and are listed in Table 3-1, were carefully studied for validity. The ozone monitor which was used to measure each value was investigated to determine whether it used the chemiluminescence principle. The data handling

## Table 3-1

## Ozone Levels Used in the Oxidant Control Plan

| Texas Region | EPA AQCR | Name | Year | High & 2nd High Ozone Conc. (ppm) | Agency Making Measurement |
|---|---|---|---|---|---|
| 3 | 212 | Austin-Waco Intrastate AQCR | 1973 | .160/.160 | TACB |
| 5 | 214 | Corpus Christi-Victoria Intrastate AQCR | 1971 | .189/.184 | EPA, RTP |
| 7 | 216 | Metro Houston-Galveston Intrastate AQCR | 1974 | .277/.234 | TACB |
| 8 | 215 | Metro Dallas-Fort Worth Intrastate AQCR | 1974 | .197/.187 | TACB |
| 9 | 217 | Metro San Antonio Intrastate AQCR | 1971 | .145/.145 | EPA, RTP |
| 10 | 106 | S. Louisiana-S.E. Texas Interstate AQCR | 1973 | .380/.325 | TACB-Special Study |
| 11 | 153 | El Paso-Las Cruces-Alamogordo Interstate AQCR | 1974 | .130/.130 | TACB |

procedures were reviewed to determine whether the high ozone values were recorded on a strip chart recorder or data logger or other permanent record showing the date and time of the observation and the ozone concentration measured. Operating records were evaluated to determine whether the one hour ozone values were bracketed by valid instrument zeros and spans showing that the instrument was responding properly. Calibration procedures were reviewed to determine whether the ozone monitor was calibrated using the neutral buffered potassium iodide calibration procedure prior to the recording of the subject values. Instrument operator's records also were examined to investigate calibration data, possible equipment malfunctions and repairs, and other appropriate information. Finally, documentation on equipment installation and siting was reviewed to determine whether each instrument was located in a temperature stable environment such as an air conditioned shelter and was located according to good site location principles.

## Conclusion

The specific data used in the development of the oxidant control strategy for Texas have been checked to determine what procedures were used and what quality control practices were followed in collecting the data. Documentation of the procedures and practices used has been submitted (Refs. 3-1 and 3-2). These documents include strip charts, computer printouts, copies of operator's records, calibration dates, standard operating procedures, site descriptions and validation procedures. The review of these documents indicates that these data are basically sound for the purpose of developing the oxidant control strategy.

Discussion

The following is a discussion of the documentation for each of the seven high and second high ozone values:

Austin-Waco, Texas AQCR 212: 0.160/0.160 ppm high and second high, both values measured on May 7, 1973 at 1 p.m. and 2 p.m., respectively.

The instrument used to measure these two values was a McMillan Model 1100 chemiluminescent ozone monitor.

The ozone values were recorded on paper tape using a Datagraphics Dataquire II Datalogger and Teletype Corporation ASR 33 Teletype Print/Punch. The information punched in the tape included ozone concentration, time of observation, and was later entered into TACB's data storage computer in Austin.

The high and second high ozone values were bracketed by zero values of 0.005/0.006 volts (volts = ppm) and span values of 0.384/0.377 volts showing minimal instrument drift. The instrument zeros and spans were conducted on May 7, before the high values were measured, and on May 8, 1973.

The ozone monitor was calibrated against neutral buffered potassium iodide using an ozone generator as a secondary standard on May 3, 1973 and again on June 20, 1973 giving a calibration bracket of 0.400/.380 volts (volts = ppm). This indicates 5% calibration drift over the 48 day period.

The ozone monitor was located in a laboratory model of a Continuous Air Monitoring Station (Connie) at the TACB headquarters in Austin and according to the documentation appears to be situtated according to good site location principles on a paved parking lot adjacent to the TACB Building.

The operators' zero/span forms were studied and revealed nothing that would invalidate the data. TACB's malfunction log and validation form had not been developed at this time.

Corpus Christi, Texas AQCR 214: 0.189/0.184 ppm high and second high, both values measured on August 17, 1971 at 3 p.m. and 4 p.m., respectively, by EPA personnel from the Environmental Monitoring Branch, Research Triangle Park, N.C.

The instrument used to measure these two values was a Bendix Chemiluminescent ozone monitor.

The ozone values were recorded on a strip chart recorder showing that the two high ozone values corresponding to approximately 43% and 42% of scale occurred on August 17, 1971 at 3 p.m. and 4 p.m., respectively.

The high and second high ozone values were bracketed by instrument calibrations using neutral buffered potassium iodide which were performed on July 10, and August 18, 1971. The August 18 calibration shows that the calibration had drifted approximately 7% from the previous calibration.

The calibration completed on July 10, 1971 occurred 37 days before the high and second high ozone values were measured. The calibration was done using neutral buffered potassium iodide.

The instrument was located in a building called Vector Control which was located at 3041 Morgan Street.

The station operators correctly filled out calibration forms and response check forms. There was nothing in the operator's trip reports that would indicate that the data may be invalid.

Houston-Galveston, Texas AQCR 216: 0.277/0.234 ppm high and second high, both values measured on July 15, 1974 at 3 p.m. and 2 p.m., respectively.

The instrument used to measure these two values was a McMillan Model 1100 chemiluminescent ozone monitor.

The ozone values were recorded on paper tape using a Datagraphics Dataquire II Datalogger and Teletype Corporation ASR 33 Teletype Print/Punch. The information punched in the tape included ozone concentration data and time of observation and was later entered into TACB's data storage computer in Austin.

The high and second high ozone values were bracketed by zero values of -0.001/-0.002 volts and span values of 0.474/0.458 volts showing minimal instrument drift. The instrument zeros and spans were conducted on July 15, 1974 before the high values and again on July 17, 1974 after the high ozone values.

The ozone monitor was calibrated against neutral buffered potassium iodide using an ozone generator as a secondary standard on July 10, 1974 and again on August 7, 1974 giving a calibration bracket of 0.500/0.540 volts. This indicates 8% calibration drift over the 28 day period.

The ozone monitor was located in a standard Connie Station at 2701 13th Avenue N in Texas City and was situated on a grass field 50 feet from a gravel road. According to documentation it appears this site was located in accordance with appropriate site location principles.

The operators' logs and forms were studied and revealed nothing that would invalidate the data.

Dallas-Fort Worth, Texas AQCR 215: 0.197/0.187 ppm high and second high, the 0.197 ppm was measured at 2 p.m. on July 22, 1974 and the 0.187 ppm was measured at 3 p.m. on July 23, 1974.

The instrument used to measure these two values was a McMillan Model 1100 chemiluminescent ozone monitor.

The ozone values were recorded on paper tape using a Datagraphics Dataquire II Datalogger and Teletype Corporation ASR 33 Teletype Print/Punch. The information punched in the tape included ozone concentration and time of observation and was later entered into TACB's data storage computer in Austin.

The high and second high ozone values were bracketed by zero values of 0.000/0.000 volts. The high value was bracketed by span values of 0.383/0.379 volts and the second high value was bracketed by span values of 0.379/0.395 volts. The instrument zeros and spans were conducted on July 21, July 23, and July 24, 1974.

The ozone monitor was calibrated against neutral buffered potassium iodide using an ozone generator as a secondary standard on June 12, 1974 and again on July 24, 1974 giving a calibration bracket of 0.460/0.430 volts. This indicates 7% calibration drift over the 42 day period.

The ozone monitor was located in a standard Connie Station at 12532 Nuestra Drive in Dallas and was situated in a grass field near a school. This site was in accordance with good site location principles.

The operators's logs and forms were studied and revealed nothing that would indicate that the data were questionable.

San Antonio, Texas AQCR 217: 0.145/0.145 ppm high and second high, both values measured on August 29, 1971, and at 4 p.m. and 5 p.m., repectively, by EPA personnel from Environmental Monitoring Branch, Research Triangle Park, N.C.

The instrument used to measure these two values was a Bendix Chemiluminescent ozone monitor.

The high ozone values were recorded on a strip chart recorder on August 29, 1971 but the chart has since been lost.

The high and second high ozone values were bracketed by zeros and spans according to routine procedures on August 28 and August 30, 1971. The zero bracket was 5.0/5.0% of scale and the span bracket was 80.5/81.0% of scale which indicates no zero drift and 0.6% span drift.

The ozone monitor was calibrated using neutral buffered potassium iodide on July 29, 1971 31 days before the high and second high ozone levels were recorded. Instrument span from the date of calibration July 29, 1971 to August 28, 1971 drifted 1.8%.

The ozone monitor was located in a fire station at Hillcrest and Bandera in San Antonio, Texas.

The operators logs and trip reports were studied and indicate nothing that would invalidate the data.

Beaumont-Port Arthur, Texas AQCR 106: 0.380/0.325 ppm high and second high, both values were measured on March 7, 1973 at 11 a.m. and 12 noon, respectively.

The instrument used to measure these two values was a Bendix Chemiluminescent monitor. The standard operating procedure for this special study was to use a McMillan MEC-1000 ozone generator as a secondary standard to calibrate the monitor at approximately monthly intervals. According to the operating procedures the MEC-1000 was to be calibrated against the primary standard neutral buffered potassium iodide.

The ozone values were recorded on a strip chart recorder showing that the two high ozone values occurred on March 7, 1973 corresponding with approximately 85% and 70% of scale.

The high and second high ozone values were bracketed by zero values and span values listed on the operators zero/span form as follows:

| | March 6 | March 7 | March 8 |
|---|---|---|---|
| Zero values | 4.0 | 4.2 | 4.0 |
| Span values | 83 | 85 | 85 |

These values show minimal instrument drift over the three day period.

The ozone monitor was located at the National Weather Service Station at the Jefferson County Airport terminal south of Nederland, Texas.

The instrument operators' check sheets were examined and show no equipment malfunction according to TACB documents.

El Paso, Texas AQCR 153: 0.130/0.130 ppm high and second high, both values measured on July 11, 1974 at 12 noon and 1 p.m., repecively.

The instrument used to measure these two values was a McMillan Model 1100 chemiluminescent ozone monitor.

The ozone values were recorded on paper tape using a Datagraphics Dataquire II Datalogger and Teletype Corporation ASR 33 Teletype Print/Punch. The information punched in the tape included ozone concentration and time of observation and was later entered into TACB's data storage computer in Austin.

The high and second high ozone values were bracketed by zero values of 0.000/0.000 volts and span values of 0.189/.222 volts which were measured on July 10, 1974, and July 12, 1974, showing substantial span drift over the two day period between span checks. Additional comments indicate span line pressure greater than one inch water, possibly causing the span drift. According to TACB documentation this discrepancy was corrected in the calibration of ppm ozone concentration (Ref. 3-1).

The high and second high ozone values were bracketed by calibration values of .230/.230 volts which were conducted on June 25, 1974, and July 31, 1974, showing excellent agreement over the 36 day period. The ozone monitor was calibrated against neutral buffered potassium iodide using an ozone generator as a secondary standard. The ozone monitor was located in a standard Connie Station at 500 South Campbell Street in downtown, El Paso, Texas, an urban core site.

The operator's records reveal nothing pertaining to the validity of the ozone data other than the high span line pressure discussed above.

## 3.2 Statistical Analysis

The statistical approach taken consists of fitting an averaging-time mathematical model suggested by Larsen (Ref. 3-3), and then determining the expected value of second highest observation for the period of record, typically one year. If the observed value fell below or relatively close then the observed value was deemed to be representative and acceptable as input for the rollback model. In all cases, except for the El Paso 1974 value, the value predicted from Larsens model exceeded the measured value. This implies that the second highest measured values recorded during the baseline years may be low rather than too high.

### 3.2.1. Description of Data Base

Data from the continuous monitoring sites consists of hourly averages for oxidants. The hourly averages are computed from 5-minute averages of continuous data. If there are fewer than seven of these averages the data is rejected and an hourly average is not computed.

Note: An hourly average is computed whenever there are more than twelve values. Extra values are merely rejected. Table 3-2 and Figure 3-1 outline the cities and sites for which an analysis was conducted.

One-hour averages for oxidants are compared with the National Ambient Air Quality Standards (NAAQS) for violation analysis in Table 3-3. The standard for photochemical oxidants is .08 ppm, not to be exceeded more than once per year. A violation analysis of oxidants consists of determining whether there are two values in excess of .08 ppm, and if so, how many hourly averages exceed the value each year. Also included in this table is the percent of days in which a violation occurred. Care should be exercised in comparing percentages due to different periods of record.

### 3.2.2 Data Summary

Various descriptive statistics have been computed for oxidant concentrations for each year of record. These include arithmetic mean, geometric mean, standard geometric deviation, highest and second highest values, percent violations (i.e., number of violations divided by the number of averages available), percent of days in violation (number of days with at least one violation divided by total number of days with record available), and percent of year for which data is available (number of available averages divided by 8760).

Only non-zero values were used in the computation of the arithmetic mean, geometric mean, and standard geometric deviation. Additionally, cumulative frequency distributions of non-zero

## TABLE 3-2
## MONITORING STATIONS FOR OXIDANTS
## STATE OF TEXAS

| CITY | SITE CODE | METHOD | OPERATING AGENCY | PERIOD OF RECORD |
|---|---|---|---|---|
| Austin | 0220 081 | Chemiluminescence | U.S. EPA | 6/71 - 9/71 |
| | 0220 002 | Chemiluminescence | Texas | 3/73 - 7/73 |
| | 0220 012 | Chemiluminescence | Texas | 2/74 - 8/74, 12/74 |
| Corpus Christi | 1150 081 | Chemiluminescence | U.S. EPA | 6/71 - 9/71 |
| | 1150 019 | Chemiluminescence | Texas | 8/73 - 8/74<br>10/74 - 12/74 |
| Dallas | 1310 081 | Chemiluminescence | U.S. EPA | 6/71 - 9/71 |
| | 1310 039 | Chemiluminescence | City | 1/73 - 4/73, 8/73 - 12/73 |
| | 1310 045 | Chemiluminescence | Texas | 1/74 - 12/74 |
| El Paso | 1700 081 | Chemiluminescence | U.S. EPA; County | 6/71 - 9/71, 10/71 - 12/71 |
| | 1700 027 | Chemiluminescence | Texas | 1/74 - 12/74 |
| Houston | 2560 081 | Chemiluminescence | U.S. EPA | 6/71 - 9/71 |
| | 2560 034 | Chemiluminescence | Texas | 4/73 - 12/74 |
| | 2560 035 | Chemiluminescence | Texas | 6/72 - 1/73, 3/73 - 8/73 |
| Nederland | 3830 003 | Chemiluminescence | Texas | 6/72 - 8/73, 10/73 - 6/74<br>10/74, 12/74 |
| San Antonio | 4570 081 | Chemiluminescence | U.S. EPA | 6/71 - 9/71 |
| | 4570 036 | Chemiluminescence | Texas | 4/74 - 9/74, 12/74 |
| Texas City | 5170 002 | Chemiluminescence | Texas | 7/74 - 9/74 |
| West Orange | 5480 001 | Chemiluminescence | Texas | 5/74 - 12/74 |

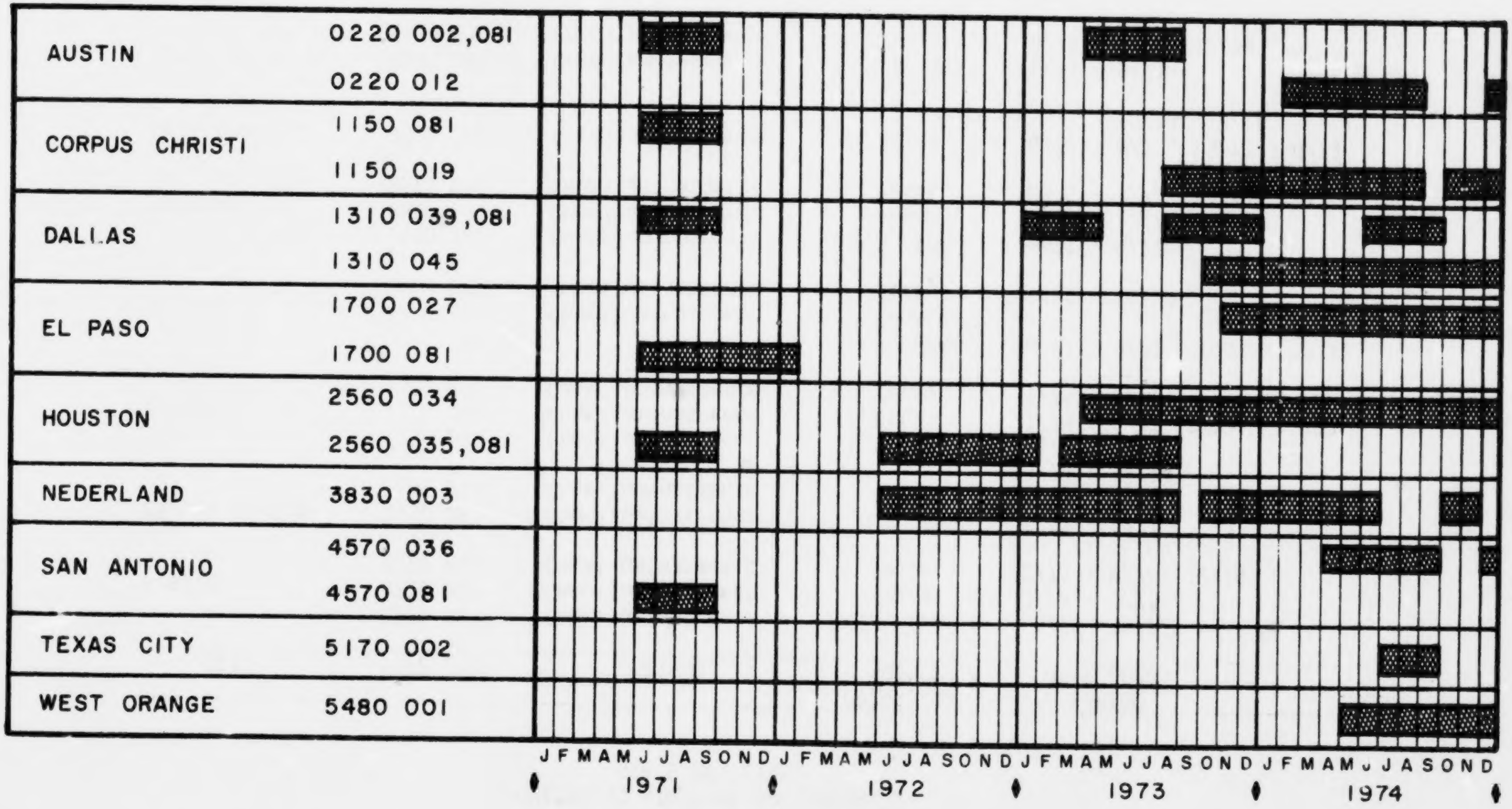

FIG. 3-1 AVAILABILITY OF DATA

## TABLE 3-3
## EXTENT OF VIOLATIONS

| | | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|
| Austin | Hi, Second Hi (ppm) | .149, .109 | | .159, .159 | .125, . 12 |
| 0220 081 (71) | % of Violations | 0.7 | | 1.7 | 2.0 |
| 002 (73) | % of Days in Violation | 5.4 | | 10.0 | 12.5 |
| 012 (74) | % Data Available | 24.4 | | 23.2 | 54.4 |
| | Hi, Second Hi (ppm) | .189, .184 | | .111, .111 | .125, .122 |
| Corpus Christi | % of Violations | 3.4 | | 1.6 | 1.1 |
| 1150 081 (71) | % of Days w/Violation | 16.7 | | 5.8 | 6.2 |
| 019 (73 & 74) | % Data Available | 24.3 | | 25.9 | 79.7 |
| | Hi, Second Hi (ppm) | .135, .125 | | .128, .126 | .170, .159 |
| Dallas | % of Violations | 1.8 | | 1.6 | 3.5 |
| 1310 081 (71) | % of Days w/Violation | 13.5 | | 8.5 | 16.2 |
| 039 (73 & 74) | % Data Available | 24.3 | | 60.1 | 29.7 |
| | Hi, Second Hi (ppm) | | | | .197, .187 |
| Dallas | % of Violations | | | | 3.6 |
| 1310 045 | % of Days w/Violation | | | | 14.8 |
| | % Data Available | | | | 71.1 |
| | Hi, Second Hi (ppm) | .130, .120 | | | .130, .130 |
| El Paso | % of Violations | 0.1 | | | 0.4 |
| 1700 091 (71) | % of Days w/Violation | 1.7 | | | 4.4 |
| 027 (74) | % Data Available | 53.8 | | | 74.6 |
| | Hi, Second Hi (ppm) | | | .255, .246 | .219, .204 |
| Houston | % of Violations | | | 5.1 | 3.0 |
| 2560 034 | % of Days w/Violation | | | 24.8 | 19.2 |
| | % Data Available | | | 56.3 | 80.9 |

## TABLE 3-3
## EXTENT OF VIOLATIONS (Contd.)

| | | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|
| Houston | Hi, Second Hi (ppm) | .155, .150 | .424, .379 | .164, .159 | |
| 2560 081 (71) | % of Violations | 1.9 | 5.6 | 2.2 | |
| 035 (72 & 73) | % of Days w/Violation | 18.8 | 24.8 | 14.0 | |
| | % Data Available | 29.5 | 56.3 | 57.3 | |
| | Hi, Second Hi (ppm) | | .317, .311 | .379, .324 | .187, .173 |
| Nederland | % of Violations | | 11.5 | 9.6 | 3.3 |
| 3830 003 | % of Days w/Violations | | 38.0 | 33.6 | 17.0 |
| | % Data Available | | 47.6 | 72.0 | 52.8 |
| | Hi, Second Hi (ppm) | .145, .145 | | | .149, .117 |
| San Antonio | % of Violations | 2.8 | | | 0.4 |
| 4570 081 (71) | % of Days w/Violation | 13.8 | | | 4.3 |
| | % Data Available | 25.1 | | | 36.9 |
| | Hi, Seoncd Hi (ppm) | | | | .277, .234 |
| Texas City | % of Violations | | | | 4.8 |
| 5170 002 | % of Days w/Violations | | | | 26.0 |
| | % Data Available | | | | 11.9 |
| | Hi, Second Hi (ppm) | | | | .207, .195 |
| West Orange | % of Violations | | | | 4.3 |
| 5480 001 | % Days in Violation | | | | 22.0 |
| | % Data Available | | | | 38.4 |

values are provided for each city and site on an annual basis. For Houston and Nederland cumulative frequency information is provided for the periods March 1973 through December 1974 and June 1972 through June 1974, respectively.

Tables 3-4 through 3-16 summarize the available data. The tables clearly indicate the extent that the national standards are being violated. Observed oxidant levels have reached peaks in excess of five times the standard at Houston (August 5, 1972; Clinton Drive site). In 1974, peaks ranged from .125 ppm at Austin to .277 ppm at Texas City.

### 3.2.3. Analysis

In this section attention is focused on a statistical evaluation of the high air quality values that are used to determine the needed emission reductions. The approach taken is to use the second highest observed concentration for the averaging time equal to the standards. The approach taken is to approximate, as closely as possible, the distribution of air pollution concentrations.

Larsen has recommended that at least one year of almost continuous sampling is needed in applying his averaging-time model to calculate expected maximum concentrations. Since the available data base varies considerably from one AQCR to another, a more accurate estimate of the yearly maxima is possible whenever an AQCR has sampled for an entire year. Also, the probability of measuring the yearly maximum concentrations decreases as the data base diminishes. The number of data points used for the analysis in each region is listed in Column 8 of Table 3-4 through 3-16.

CITY: Austin
SITE CODE: 0220 081 A05 (71)
0220 002 F01

## TABLE 3-4
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | .149 | .109 | 93 | 5 | 5.4 | 14 | 2134 | 0.7 | 24.4 | 6/71 - 9/71 |
| 1973 | .159 | .159 | 111 | 7 | 6.3 | 35 | 2348 | 1.5 | 26.8 | 3/73 - 7/73 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1971 | -- | -- | .080 | .050 | .040 | .030 | .025 | .025 |

CITY: **Austin**
SITE CODE: 0220 012 F01

## TABLE 3-5
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | .125 | .112 | 192 | 24 | 12.5 | 93 | 4594 | 2.0 | 52.4 | 2/74 - 8/74 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

| | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1974 | .125 | .109 | .088 | .054 | .044 | .038 | .032 | .028 |

CITY: Corpus Christi
SITE CODE: 1150 081 A05 (71)
091 F01

## TABLE 3-6
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | .189 | .184 | 72 | 12 | 16.7 | 73 | 2126 | 3.4 | 24.3 | 6/71 - 9/71 |
| 1973 | .111 | .111 | 104 | 6 | 5.8 | 36 | 2265 | 1.6 | 25.9 | 8/73 - 12/73 |
| 1974 | .125 | .122 | 321 | 20 | 6.2 | 77 | 6984 | 1.1 | 79.7 | 1/74 - 8/74<br>10/74 - 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

| | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1971 | .189 | .179 | .110 | .045 | .025 | .020 | .020 | .015 |
| 1973 | .111 | .111 | .091 | .040 | .032 | .026 | .021 | .017 |
| 1974 | .125 | .111 | .083 | .043 | .032 | .026 | .021 | .018 |

CITY: Dallas
SITE CODE: 1310 081 A05 (71)
1310 039 H01

## TABLE 3-7
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | .135 | .125 | 96 | 13 | 13.5 | 38 | 2125 | 1.8 | 24.3 | 6/71 - 9/71 |
| 1973 | .128 | .126 | 270 | 23 | 8.5 | 85 | 5266 | 1.6 | 60.1 | 1/73 - 4/73<br>8/73 - 12/73 |
| 1974 | .170 | .159 | 111 | 18 | 16.2 | 91 | 2601 | 3.5 | 29.7 | 6/74 - 9/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1971 | -- | -- | .095 | .050 | .035 | .030 | .020 | .015 |
| 1973 | .128 | .111 | .095 | .049 | .037 | .029 | .024 | .020 |
| 1974 | .170 | .159 | .101 | .057 | .043 | .034 | .029 | .023 |

CITY: Dallas
SITE CODE: 1310 045 F01

TABLE 3-8
SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | .197 | .187 | 290 | 43 | 14.8 | 226 | 6229 | 3.6 | 71.1 | 1/74 - 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1974 | .197 | .159 | .110 | .061 | .047 | .038 | .032 | .026 |

CITY: El Paso
SITE CODE: 1700 091 G01 & 081 A05
027 F01 (1974)

TABLE 3-9
SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | .130 | .120 | 178 | 3 | 1.7 | 6 | 4716 | 0.1 | 53.8 | 6/71 - 9/71<br>10/71 - 12/71 |
| 1974 | .130 | .130 | 297 | 13 | 4.4 | 27 | 6538 | 0.4 | 74.6 | 1/74 - 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1971* | -- | -- | .075 | .055 | .045 | .045 | .040 | .035 |
| 1974 | .130 | .100 | .069 | .043 | .035 | .030 | .026 | .022 |

*Summer study data only

CITY: Houston
SITE CODE: 2560 034 F01

## TABLE 3-10
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1973 | .255 | .246 | 201 | 50 | 24.9 | 212 | 4181 | 5.1 | 47.7 | 4/73 - 12/73 |
| 1974 | .219 | .204 | 328 | 63 | 19.2 | 215 | 7083 | 3.0 | 80.9 | 1/74 - 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1973 | .255 | .226 | .137 | .068 | .044 | .032 | .024 | .017 |
| 1974 | .219 | .162 | .120 | .055 | .039 | .029 | .023 | .017 |

CITY: Houston
SITE CODE: 2560 081 A05
2560 035 F01

## TABLE 3-11
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | .155 | .150 | 96 | 18 | 18.8 | 48 | 2583 | 1.9 | 29.5 | 6/71 - 9/71 |
| 1972 | .424 | .379 | 214 | 53 | 24.8 | 275 | 4929 | 5.6 | 56.3 | 6/72 - 12/72 |
| 1973 | .164 | .159 | 215 | 30 | 14.0 | 111 | 5019 | 2.2 | 57.3 | 1/73, 3/73 - 8/73 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1971 | -- | -- | .100 | .045 | .030 | .020 | .015 | .010 |
| 1972 | .424 | .329 | .199 | .074 | .049 | .029 | .024 | .019 |
| 1973 | .164 | .144 | .114 | .054 | .044 | .034 | .024 | .019 |

CITY: **Nederland**
SITE CODE: 3830 003 F01

## TABLE 3-12
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | .317 | .311 | 187 | 71 | 38.0 | 480 | 4169 | 11.5 | 47.6 | 6/72 - 12/72 |
| 1973 | .379 | .324 | 286 | 96 | 33.6 | 607 | 6303 | 9.6 | 72.0 | 1/73 - 8/73<br>10/73 - 12/73 |
| 1974 | .187 | .173 | 218 | 37 | 17.0 | 154 | 4628 | 3.3 | 52.8 | 1/74 - 6/74<br>10/74 - 11/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1972 | .317 | .293 | .166 | .089 | .059 | .042 | .033 | .025 |
| 1973 | .379 | .241 | .150 | .079 | .069 | .048 | .039 | .032 |
| 1974 | .187 | .152 | .109 | .060 | .044 | .035 | .030 | .026 |

CITY: San Antonio
SITE CODE: 4570 081 A05
036

## TABLE 3-13
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1971 | .145 | .145 | 94 | 13 | 13.8 | 61 | 2195 | 2.8 | 25.1 | 6/71 - 9/71 |
| 1974 | .149 | .117 | 162 | 7 | 4.3 | 15 | 3238 | 0.4 | 36.9 | 4/74 - 9/74, 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

| | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1971 | .145 | .145 | .105 | .050 | .040 | .035 | .030 | .024 |
| 1974 | * * * * * * * NOT AVAILABLE * * * * * * * * * | | | | | | | |

CITY: Texas City
SITE CODE: 5170 002 F01

## TABLE 3-14
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | .277 | .234 | 50 | 13 | 26.0 | 50 | 1041 | 4.8 | 11.9 | 7/74 - 9/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1974 | .277 | .234 | .142 | .062 | .050 | .039 | .030 | .021 |

CITY: West Orange
SITE CODE: 5480 001 F01

## TABLE 3-15
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | .207 | .195 | 159 | 35 | 22.0 | 144 | 3363 | 4.3 | 38.4 | 5/74 - 12/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| 1974 | .181 | .179 | .144 | .072 | .047 | .038 | .030 | .023 |

CITY: Houston
Nederland
SITE CODE: 2560 034 F01
3830 003 F01

## TABLE 3-16
## SUMMARY OF DATA

| YEAR | HIGHEST | SECOND HIGHEST | NO. DAYS WITH DATA | NO. DAYS WITH VIOLATIONS | % DAYS IN VIOLATION | NUMBER OF VIOLATIONS | NO. OF HOURLY AVERAGES | % VIOLATIONS | % OF DATA AVAILABLE | PERIOD OF RECORD FOR WHICH DATA IS AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|---|
| Houston 1973 - 1974 | .255 | .246 | 529 | 113 | 21.4 | 427 | 11,264 | 3.8 | 64.3 | 4/73 - 12/74 |
| Nederland 1972 - 1974 | .379 | .324 | 691 | 204 | 29.5 | 1241 | 15,100 | 8.2 | 57.4 | 6/72 - 8/73<br>10/73 - 6/74<br>10/74 - 11/74 |

CUMULATIVE FREQUENCY DISTRIBUTIONS
PERCENT OF TIME VALUE IS EXCEEDED

|  | .01 | .1 | 1 | 10 | 20 | 30 | 40 | 50 |
|---|---|---|---|---|---|---|---|---|
| Houston 1973 - 1974 | .255 | .197 | .128 | .059 | .040 | .030 | .023 | .017 |
| Nederland 1972 - 1974 | .324 | .268 | .147 | .076 | .055 | .042 | .034 | .028 |

Because of the lack of sufficient historical data in some of the AQCRs and because maximum concentrations vary markedly from year to year, it is impossible to determine if the second high value being used comes from a "clean year," a "dirty year," or an average year. The probability, however, is high that the specific value chosen is not the all time second high that could be generated by the worst combination of meteorology, site location, and emissions. Thus it seems reasonable to assume that the use of the available data would not overstate the severity of the air quality problem.

The above limitations clearly indicate the need to develop techniques which may be used to predict maxima and to evaluate statistically the credibility of the observed peak values. The method being adopted is attributable to Dr. Ralph I. Larsen of EPA's National Environmental Research Center in Research Triangle Park, North Carolina. Larsen suggests the use of the expected value for the annual maximum concentration as the design value on which to base control strategies. If control strategies are developed and applied based on this expected value, then the standard can be expected to be violated in only one out of every eight years. Similarily, the use of the second highest value measured has the expectation that a violation will occur every other year (Ref. 3-6). By use of Larsen's methods, an indication is given whether observed maxima are consistent with, and predictable from, the data or should be considered a freak event; outliers from the population represented by the data base. It should be noted that much work has been done on the question of outliers but the largeness of our sample sizes make these procedures inapplicable. Current research is being conducted to treat air quality data specifically.

### 3.2.4. The Method

Previous reports by Larsen (3-3, 3-4, 3-5, 3-6) have recommended the use of an empirical mathematical model to describe air pollution data. One of the characteristics of this model is that air pollutant concentrations are lognormally distributed for all averaging times. Potential theoretical reasons for these characteristics have been cited as well (Refs. 3-7 and 3-8).

The lognormal distribution is a left-skewed distribution. A histogram of lognormally distributed data would have a short left tail, a hump skewed to the left, and a very long right tail. In air quality data, this indicates the abundance of lower concentrations and a few very high concentrations. This distribution can be easily transformed to the well-known normal distribution by considering the natural logarithms of the concentrations rather than the concentrations themselves. However, a histogram plot of this nature would give little more than a qualitative description of concentrations. A simpler evaluation of the data rests on another feature of the lognormal distribution. When the cumulative frequency distribution is plotted on log-probability paper, a straight line is produced when the data are perfectly lognormally distributed (Ref. 3-3). Let us suppose that there exists an infinite population of possible one-hour ozone concentrations. When viewing each hourly average as an observation from this distribution, a sample of size 8760 would represent all the hourly averages possible in a non-leap year. If the sample is representative of the population sampled, then empirically the data should produce a plot on log probability paper which is fairly linear. If such is the case, then the observed concentrations may be used to generalize the potential population of concentrations.

The lognormal distribution is completely described by two parameters, the geometric mean and the standard geometric deviation. The first task with any body of data which appears to fit the lognormal model is to estimate these two parameters from the sample values. These estimates can then be used to calculate expected maxima which may be compared to the observed peaks. We may then determine whether recorded peaks are typical and expected, or represent outliers from the total population.

The straight line representing the lognormal distribution on log-probability paper is used to provide estimates of the two parameters, since the slope of this line is related to the standard geometric deviation and the point at which this line crosses the 50th percentile point is equal to the geometric mean. Theoretically, any chosen set of two points to determine the slope should give the same result. However, with the data in question this is clearly not the case in many instances. Oxidant concentrations seem to depart from lognormality in the extreme upper tail exhibiting a tapering-off effect. This is suggestive of a mixture of distribution functions more adequately representing these concentrations. Larsen suggests that drawing the lognormal line through the .1 and 30th percentile points should provide an adequate fit for determining the expected annual maximum and expected annual second high.

Two methods were used in assessing the validity of the lognormal assumption. One, as indicated previously, is to plot each hourly average on log-probability paper and if the resulting plot is fairly linear this indicates that the distribution of these averages is lognormal. Another way by which one might assess the validity of this assumption is to plot 1-F(x) versus concentration on semi-log paper, where concentration in ppm is plotted along the abscissa and F(x) equals the cumulative frequency. If the resulting plot bends upward, see Figure 3-2, the distribution is classified as heavy-tailed; the lognormal distribution is a member of this class of distributions (Ref. 3-8). The largeness of the data bases involved made plotting each point prohibitive. Instead only a few selected points were plotted.

We turn now to how the expected maximum concentrations were obtained. If the population of concentrations had been subjected to 100% sampling, i.e., 8760 hourly averages, and were totally accurate, then a good estimate for the expected yearly maximum for a particular year would be the observed maximum for the year. Likewise for the second highest value. However, 100% sampling is not available for any of the sites, maxima vary markedly from year

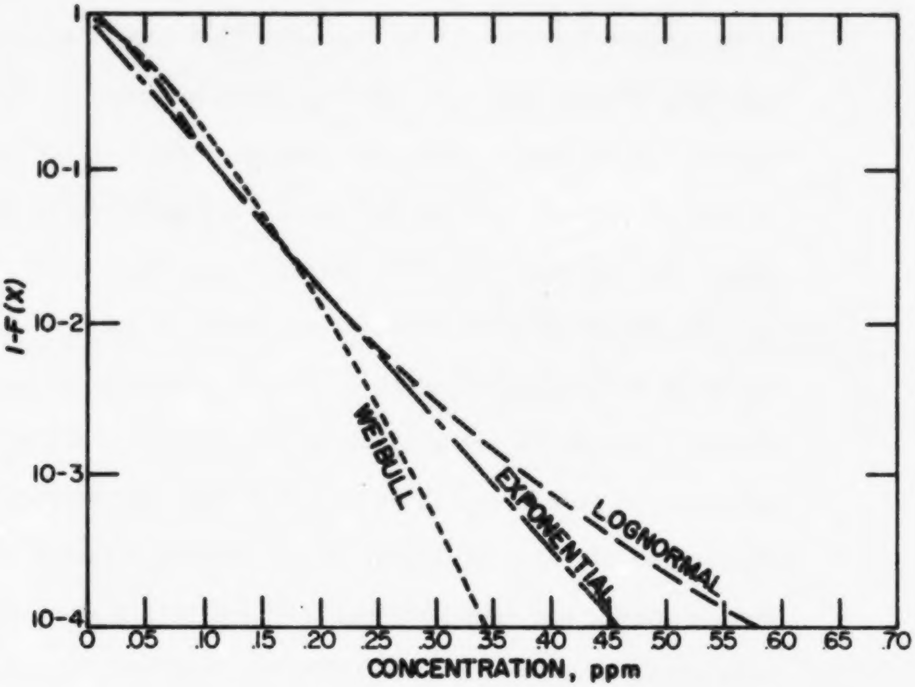

Figure 3-2 - 1-F(x) vs. Concentration

to year, and as mentioned previously, there is also the possibility that the actual maximum concentrations went unobserved and unrecorded. This is much more probable whenever 3rd quarter data is not available (June 1 - September 30) since high values usually occur more frequently during this period of time. Hence a better estimate of the 2nd highest value would be its expected value which is calculated by use of the estimated parameters of the model. Using this expected value, one can ascertain that the value chosen for input into the reduction model is consistent with the body of data and does not represent an anomaly. The expected values obtained were those that one would expect during the period of record and not necessarily those that would occur for the entire year. For example, in 1971, data for San Antonio was available for the months of June through September, hence the calculated expected value is that which the model predicts for that period of record. One would not want to extrapolate over the entire year because the sample available probably does not represent the true proportion of concentrations likely to have occurred during the entire year. Had sampling been for the entire year, the lognormal line would have resulted in different (and more accurate) estimates of the population geometric mean and standard geometric deviation.

### 3.2.5. Results of Analysis

The expected maximum and second high concentrations for each year were estimated using the method previously described. Appendix A gives an example of the procedure used in attaining these values. In Tables 3-17 through 3-25 observed values are

CITY: Austin
SITE CODE: 0220 002 (1973)
0220 012

### TABLE OF MODEL ESTIMATORS
### HIGHEST AND SECOND HIGHEST CONCENTRATIONS
### OBSERVED VS. ESTIMATED

TABLE 3-17

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1973 | .024 | .022 | 1.91 | .159 | .159 | .226 | .194 |
| 1974 | .030 | .031 | 1.51 | .125 | .112 | .144 | .129 |

CITY: Corpus Christi
SITE CODE: 1150 081 (1971)
1150 019

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-18

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1971 | .022 | .013 | 2.35 | .189 | .184 | .282 | .218 |
| 1973 | .021 | .019 | 1.76 | .111 | .111 | .145 | .127 |
| 1974 | .022 | .019 | 1.76 | .125 | .122 | .164 | .143 |

CITY: Dallas
SITE CODE: 1310 039 (1973 - 74)
1310 045 (1974)

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-19

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1973 | .024 | .022 | 1.69 | .129 | .126 | .155 | .133 |
| 1974 | .028 | .025 | 1.82 | .170 | .149 | .216 | .180 |
| 1974 | .031 | .028 | 1.75 | .197 | .187 | .236 | .206 |

CITY: El Paso
SITE CODE: 1700 081 (1971)
1700 027

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-20

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1971 | .021 | .019 | 1.55 | .074 | .074 | .087 | .077 |
| 1974 | .023 | .023 | 1.60 | .130 | .130 | .138 | .123 |

CITY: Houston
SITE CODE: 2560 035 (1972 - 73)
2560 034 (1973 - 74)

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-21

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1972 | .031 | .018 | 2.57 | .424 | .379 | .603 | .472 |
| 1973 | .026 | .026 | 1.175 | .164 | .159 | .209 | .180 |
| 1973 | .027 | .022 | 2.14 | .255 | .245 | .373 | .340 |
| 1974 | .024 | .021 | 1.95 | .219 | .204 | .268 | .229 |

CITY: Nederland
SITE CODE: 3830 003

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-22

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1972 | .038 | .028 | 2.13 | .317 | .311 | .466 | .383 |
| 1973 | .040 | .035 | 1.87 | .379 | .324 | .380 | .327 |
| 1974 | .030 | .026 | 1.77 | .187 | .173 | .218 | .188 |

CITY: San Antonio
SITE CODE: 4570 091 (1971)
4570 036

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-23

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1971 | .027 | .026 | 1.74 | .145 | .145 | .191 | .162 |
| 1974 | * | * | * | .149 | .117 | * | * |

* Not computed due to only a partial retrieval of data from NADB

CITY: Texas City
SITE CODE: 5170 002

## TABLE OF MODEL ESTIMATORS
## HIGHEST AND SECOND HIGHEST CONCENTRATIONS
## OBSERVED VS. ESTIMATED

TABLE 3-24

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1974 | .030 | .027 | 2.08 | .277 | .234 | .320 | .252 |

CITY: West Orange
SITE CODE: 5480 001

TABLE 3-25

### TABLE OF MODEL ESTIMATORS
### HIGHEST AND SECOND HIGHEST CONCENTRATIONS
### OBSERVED VS. ESTIMATED

| YEAR | ARITHMETIC MEAN | GEOMETRIC MEAN | STD. GEOMETRIC DEVIATION | OBSERVED HIGHEST | OBSERVED 2nd HIGHEST | ESTIMATED HIGHEST | ESTIMATED 2nd HIGHEST |
|---|---|---|---|---|---|---|---|
| 1974 | .032* | .028* | 1.83* | .207** | .195** | .244* | .191* |

* Based on Third Quarter Data Only
** Observed during entire period of record

compared to those predicted by the model. The predicted values are those that would be expected had 100% sampling during the entire period of record been performed, hence in some cases the predicted values are considerably higher. When this extrapolation is not performed, model estimates more closely approximate the observed values. For each site, model estimates and observed values were compared using the points 1(1)5(5)50. It was found that the mean difference between these values ranged from .014 ppm underprediction to .006 ppm overprediction, with standard deviations ranging from .004 ppm to .045 ppm. These results are presented in Table 3-26. Figures 1 through 18 of Appendix A provide a visual assessment of the lognormal fit. The points 1(1)5(5)50 as well as the .01, .1, 10, 20, and 30th precentile points were plotted on log probability paper and a line drawn through the .1 and 30th percentile. For the graphs on semi-log paper the points plotted were, 1-F(x) = .0001, .001, .01, .10, .20, . . ., .90. The theoretical distribution derived from using the estimated parameters is plotted alongside the observed frequency for the graphs on semi-log paper. Thus, the model used appears to be a reasonable approximation to the distribution of oxidant concentrations and the model estimates of the maximum values lend credibility to the occurrence of the levels that were measured at each site. The estimated values appearing in Tables 1 through 18 of Appendix A are indicative of what could have occurred.

## TABLE 3-26
## MEAN AND STANDARD DEVIATION OF PREDICTED MINUS OBSERVED VALUES

$\bar{D}$ = Mean Difference s = standard deviation

| SITE | YEAR | $\bar{D}$ | s |
|---|---|---|---|
| Austin | 1973 | .005 | .015 |
| Austin | 1974 | .000 | .007 |
| Corpus Christi | 1971 | - .008 | .022 |
| Corpus Christi | 1974 | - .002 | .011 |
| Dallas (039) | 1973 | - .001 | .011 |
| Dallas (039) | 1974 | - .002 | .011 |
| Dallas (045) | 1974 | - .002 | .011 |
| El Paso | 1971 | .002 | .003 |
| El Paso | 1974 | - .003 | .004 |
| Houston (034) | 1973 | - .001 | .026 |
| Houston (034) | 1974 | - .004 | .019 |
| Houston (035) | 1972 | - .014 | .045 |
| Houston (035) | 1973 | - .005 | .015 |
| Nederland | 1972 | .006 | .034 |
| Nederland | 1973 | .001 | .007 |
| Nederland | 1974 | - .004 | .011 |
| San Antonio | 1971 | - .003 | .011 |
| Texas City | 1974 | .004 | .013 |

MINUS SIGN (-) INDICATES UNDER PREDICTION

The results also indicate that the assumption of lognormality is a reasonable one and that the observed second high does not appear to have been an anomaly for any of the sites during the baseline years. As shown in Table 3-20, El Paso's second high reading is higher than expected. However, it is close enough to be used in the rollback model, judging from the variability of mean differences. This is especially true when one considers the fact that use of the second high value has the expectation that the national standards will be violated almost every year.

### 3.2.6. Model Limitations

Some possible limitations in the results should be noted. Estimated values for maximum concentrations are highly dependent on the choice of points used for estimation of the lognormal parameters. The .1 and 30th percentile points were selected since a lognormal line drawn through these two points adequately represents the upper 30% of the distribution. It has been noted that air sample concentrations are not independent of each other, as is required for model use. Ozone levels have a pattern of seasonal and diurnal variation, higher levels occurring mostly in the spring and summer between the hours of 10 a.m. and 5 p.m.. Some dependence may also exist between sequential observations due to relatively slow variability in the dominant parameters influencing air quality. This non-independence of data appears to cause an overestimate of the expected maxima, which is almost balanced out by the mathematical approximation used in computation--which tends to underestimate maxima. Neustadter and Sidik have used a Monte Carlo technique and calculated the underestimate to be about 4 to 8% (Ref. 3-10).

Another limitation lies in the inability to test the goodness of fit of the model by some criteria. Only a visual assessment of such goodness of fit was presented.

### 3.2.7. Conclusions

Although the mathematical model used to describe the distribution of oxidant levels has some limitations, it is seen that it can adequately estimate the air quality levels and hence, lends credibility to the fact that recorded values are consistent with the body of the data for the period of record and do not represent anomalies. These estimated values have been presented alongside the actual observed peak occurrences. Thus the use of the second high observed during designated baseline years are justified for use in determination of needed source reductions.

## 3.3 Meteorological Analysis

A recent study (Ref. 3-13) was conducted for the following purposes: To evaluate the meteorological conditions which coincide with high ozone measurements in the seven Texas AQCR's; to determine the extent to which certain meteorological conditions characterize the high ozone days; to determine the expected frequency of occurrence of high ozone days; and to examine the meteorology of the seven high and second high ozone values which are the basis of this oxidant control plan.

### 3.3.1 Description of Data Base

In order to evaluate and characterize meteorological conditions associated with high ozone days, groups of meteorological data were collected for the ten highest ozone days for each year, 1971-1974, at eleven monitoring stations (totaling 24 station years available) representing the seven AQCR's. The meteorological data collected included solar insolation, temperature, sea level pressure, wind speed, wind direction range, time of day, season of year, and comparison with stability/wind frequency distribution ("STAR" data).

### 3.3.2 Description of Data and Method of Analysis

The following section is a discussion of the method of analysis and data utilized to perform the analysis. It should be emphasized that this study is totally retrospective in nature. Data used in this analysis, both ozone and meteorological, were recorded and reported for different purposes and were sometimes not readily compatible. While some parameters known to be reported would seem easily comparable, frequently other approaches had to be devised once the data was reviewed.

#### Solar Insolation

Solar altitude for any hour and day at a given latitude may be calculated to an accuracy of within one degree. Solar radiation in langleys per minute cannot be calculated readily without precise information describing the absorptive characteristics of the atmosphere in which the short wave radiation travels. Therefore, the accuracy inherent in a calculation of solar altitude would be lost if calculated solar radiation were the sole parameter used to characterize solar insolation.

In characterizing solar insolation on high oxidant days in Texas, both solar altitude and solar radiation classes were used. Since only afternoon hours for Texas high ozone days were used in the calculations of solar radiation index, only the indices 0 through 4 would be expected at noon. Further, since most days had unlimited ceilings and less than 50 percent cloud cover, it would also be expected that predominately the classes three and four would result at this hour of peak solar insolation. Maximum daily solar altitude was tabulated in five degree increments for characterization of the days of the 10 highest ozone concentrations.

### Temperature

For the purpose of characterizing the temperature of the high ozone day, both the temperature at the hour of recorded high ozone concentration as well as the average daily temperature, were tabulated within 10 degree temperature intervals. When the hour of recorded high ozone occurred between two reported hours, an interpolation was obtained between these values. Although this method assumes the temperature was between that reported at the three hour intervals, the probability is greater that the interpolated value represents the actual temperature at that hour than if either of the two surrounding hours were chosen. Further, in light of the fact that values used to characterize the temperature at an urban ozone monitoring site were reported from the meteorological station within closest proximity, this loss of accuracy due to interpolation is within the boundaries of allowable error.

### Surface Pressure

The synoptic climatology of Texas is such that in the seasons of high insolation, centers of high pressure over the state occur less frequently than many locations which have served to define classical oxidant formation theory. This observation is further complicated in the western portions of Texas where the synoptic climatology is often dominated by a semi-permanent "heat low."

Accordingly, each high value case was classified as to whether anti-cyclonic or cyclonic curvature prevailed over the area of interest. Cases where the curvature was ill-defined were classified as neutral. Cases which were well-defined as having either ridges or centers of high ozone presure in the area of interest were also noted as such.

Sea level pressure at 7:00 a.m. was obtained from the surface weather maps. Where climatological stations were not within close proximity, interpolations were made between surface pressure values observed at two or more stations as appropriate. Each surface pressure value was then compared to the climatological average sea level pressure for the month when the high ozone day occurred in order to determine if the pressure was generally higher or lower than average. This information may be considered supplementary to the extent that there may be high or low pressures dominating large portions of the country, with Texas receiving relatively ill-defined curvature.

The prevalence of anti-cyclonic curvature over the area on a high ozone day should be considered exemplary of the classical theory to the extent that the area is under the influence of high pressure. It must be reemphasized, however, that stations in the western part of the state such as El Paso would not have such conditions in view of the predominace of the spring and summer "heat low" in that area. Finally, the daily weather maps were carefully checked to determine if a "peak" synoptic condition was consistently producing the high $O_3$ readings.

Time of Day

The time of day for the 10 highest values were tabulated according to their occurrence during one of four periods in the day in local standard time as follows:

(0000 - 0500)
(0600 - 1100)
(1200 - 1700)
(1800 - 2300)

Season

For the seasonal analysis of the 10 highest ozone days, each case was tabulated as to its occurrence in one of the following four seasons: (January-March), (April-June), July-September), (October-December).

In comparing Texas with other locations it should be noted that the solar altitude will be greater year round in Texas than, for instance, the northern East Coast corridor. If other meteorological varibles are held equal, which they are not, the ozone season would be longer in Texas than most of the locations which have defined classical theory. Therefore, occurrences of high ozone concentrations in the afternoon of off-season days may be considered valid if the other classical meteorological conditions occur.

### Wind Speed

The frequency distribution of wind speed by classes (0-3 mph, 4-7 mph, 8-17 mph, 13-18 mph, 19-24 mph, and ≥ 25 mph) for all high values in each set was compared to the climatological distribution, the latter as defined by data obtained from the Climatic Atlas of the United States, June 1968. Each high value wind speed was defined by the average wind speed for the two observations surrounding a violation hour. On those days when more than one high value occurred, only one wind speed value was extracted; that being the average wind speed over all hours immediately before or after any of the high values on that day. Next, average wind speed for all high values in a set was calculated and compared to the climatological norm as given by the local Climatological Data Summaries.

Care must be taken in interpreting this tabulation since winds are generally lighter in summer yet generally stronger in the afternoon than the climatological norm with the latter effect the more pronounced.

### Wind Direction

A tabulation was made of the range of the wind direction over the six hour period up to and including the high value hour. Each range was then classified according to the following classes which define wind variability:

0° - 45° Steady
45° - 90° Average Variability
> 90° Extreme Variability

Although these categories are somewhat arbitrary a precise definition of wind variability in the literature does not exist. This methodology is loosely based on work by Singer at Brookhaven National Laboratory in 1967. It is recognized that the climatology of New York is significantly different from that of Texas; however, examination of wind rose and resultant wind data for four Texas weather stations (Dallas, Houston, San Antonio, and El Paso) revealed that the wind is apt to be steadier in Texas than in New York (because the prevailing directions and resultant speeds are much more pronounced in the former case), so that if anything the classifications used should be considered a bit conservative (i.e., perhaps ranges smaller than 90° should be classified as "extremely variable").

### Wind Distribution by Pasquill Stability Class

The final step in the analysis was to classify the combination of wind direction, speed and stability which occurred at each of three afternoon hours (1200, 1500, and 1800) on each high value day, and compare the results for each of the three sets of frequency distributions (highest values, second highest values, and 10 highest values) for each station to the appropriate climatological distributions (as derived from the "STAR" program).

For the "highest" and "second highest" sets, results are evaluated in terms of the number of combinations considered which fell in normally very infrequent categories (0.0 to 0.2 percent frequency within the given stability class), in rather infrequent categories (0.3 to 0.5 percent frequency within the stability class), in "average" frequency categories (0.6 to 1.4 percent frequency within the stability class), in rather frequent categories (1.5 to 5.0 percent), and in extremely frequent categories (>5.0 percent). Combinations or "parts" of combinations (such as a certain wind direction) which persistently reoccurred for a monitoring site are additionally noted. An intra-stability analysis was emphasized; that is, a given combination was classified based on its normal frequency of occurrence compared to the remaining combinations within the class (i.e., the climatological frequencies of occurrence for all wind combinations had up to 100 percent for each class). This was felt to be necessary because of the obvious bias toward unstable Pasquill classes resulting from the evaluation of just the afternoon hours, which in turn would bias a comparison of results with normal frequency of occurrence relative to all observations. However, it is recognized that there may be an unusually high percentage of A or B stability cases, even considering the time of day.

For the data sets representing the 10 highest values, the complete frequency distributions were collected, for each stability and for all stabilities combined. The percentages for each stability class are relative to the total number of cases only within each class.

Again, unusually high frequencies of A or B stability, even considering the time of day, are noted where applicable.

In most cases the comparisons were made with the appropriate seasonal "STAR" frequency distributions, which were usually for the period June-August. However, individual exceptions to the latter did occur for high and second high days at various stations, as well as for the groups of ten highest days at Clute (for which September-November data were used) and Corpus Christi (for which annual data were used, since high values were scattered throughout the year).

The comparison with "STAR" data was only accomplished for eight of the eleven stations; "STAR" data for Austin and Port Arthur (Nederland and West Orange stations) were not available at the time of this report.

The analyses were based on information from several data sources, which in some cases were not available for the particular city of interest. In these situations, data from the closest or most representative climatic station relative to the monitoring site was used. Thus, the basic meteorological data for the Clute, Aldine, and Texas City sites were taken from the LCD's (Local Climatological Data Summaries) for Houston, Texas, while LCD's for Port Arthur, Texas were used for the Nederland and West Orange analyses. Concerning the Texas City analysis, LCD's for Galveston, Texas (the closest major city) were sought out originally; however, only monthly summaries were available, so it was decided to use the Houston climatic data instead.

### 3.3.3 Analysis of the High Ozone Days

This section summarizes the analysis of the meteorological parameters defined in the previous section and also discusses the expected frequency of occurrence of the high ozone days.

#### 3.3.3.1 Meteorological Characteristics

Based on the ten highest ozone days for each year, 1971-1974, at the eleven monitoring stations, the following conclusions have been drawn regarding characterization of the meteorological parameters associated with those days:

Solar Insolation: high solar radiation; high solar altitude; and less than 50% cloud cover.

Temperature: high ambient temperature.

Surface Pressure: weak pressure gradient; not necessarily associated with anti-cyclonic curvature.

Time of Day: late morning to early evening.

Season: late spring through autumn; especially summer months.

Wind Speed: light to moderate.

Wind Direction Range (Variability): not significantly associated.

The above meteorological parameters were considered characteristic for a given station year if a good majority (75% or more) of the high cases exhibited these conditions with respect to a good majority (75% or more) of the parameters analyzed. Seventeen of the 24 station years satisfied this condition with respect to all of the 10 highest ozone measurements. The following station years were uncharacteristic as indicated:

Austin-1973: quite a few unusual cases were evident and only season of year was considered characteristic.

Clute-1974 and Nederland-1972 and 1973: were uncharacteristic with respect to season.

Corpus Christi-1971: was unusual with respect to wind speed.

Corpus Christi-1973: was unusual with respect to wind speed and season of year.

El Paso-1971: was characterized by relatively low temperature.

#### 3.3.3.2 Frequency of High Values

Based on the eight stations for which comparisons with "STAR" data were made, it was concluded that the high ozone days are not generally characterized by extremely unusual meteorological conditions (i.e., those with less than 0.2% climatological frequency of occurrence within the stability class). The highest percentages of high ozone measurements associated with such extremely unusual meteorology occurred in Dallas (22%), Houston (14%), and Texas City (13%).

The most frequently reoccurring highly unusual combination was A stability with calm winds which accounted for about one-third of all the extremely unusual cases. Nearly half of the highly unusual combinations occurred with A stability and approximately 20% were combinations of C stability with uncharacteristically low wind speeds.

Thus it can be seen that the highly unusual conditions characterized only a small minority of the weather observations analyzed and most of the unusual conditions were characterized by unstable atmosphere with low wind speeds.

### 3.3.4 Analysis of the Seven High and Second Highs

#### 3.3.4.1 Austin - 5/7/73

Solar Insolation: high solar altitude (77°); high solar radiation (index 4); no cloud cover.

Temperature: high (80°)

Sea Level Pressure: moderate cyclonic curvature

Wind Speed: high (13 mph)

Wind Direction Range: steady

Time of Day: afternoon (1300 and 1400)

Season of Year: mid-spring

#### 3.3.4.2 Corpus Christi - 8/17/71

Solar Insolation: high solar altitude (75°); high solar radiation (index 4); little cloud cover (4/10).

Temperature: high (91°)

Sea Level Pressure: weak anti-cyclonic ridge

Wind Speed: moderate (9 mph)

Wind Direction Range: extremely variable

Time of Day: afternoon (1500 and 1600)

Season of Year: summer

Comparison with "STAR" Data: rather frequent (average of nearest three hours - 3.1%).

### 3.3.4.3 Dallas - 7/22/74 and 7/23/74

Solar Insolation: high solar altitude (77°, both); high solar radiation (index 4, both); little cloud cover (3/10 and 0/10).

Temperature: high (103° and 105°)

Sea Level Pressure: very weak gradient (both)

Wind Speed: light to moderate (6 and 8 mph)

Wind Direction Range: extremely variable (both)

Time of Day: afternoon (1400 and 1500)

Season of Year: summer

Comparison with "STAR" Data: rather frequent and extremely frequent (average of nearest three hours - 4.8% and 6.0%).

### 3.3.4.4 El Paso - 7/11/74

Solar Insolation: high solar altitude (74°); high solar radiation (index 4); little cloud cover (4/10).

Temperature: high (86°)

Sea Level Pressure: weak cyclonic gradient

Wind Speed: light to moderate (7 mph)

Wind Direction Range: average variability

Time of Day: afternoon (1200 and 1300)

Season of Year: summer

Comparison with "STAR" Data: rather frequent (average of three nearest hours - 2.5%).

### 3.3.4.5 Houston - 7/15/74

Solar Insolation: high solar altitude (82°); moderately high solar radiation (index 3); cloud cover significant (6/10).

Temperature: high (89°)

Sea Level Pressure: very weak gradient

Wind Speed: moderate (9 mph)

Wind Direction Range: extremely variable

Time of Day: afternoon (1300 and 1400)

Season of Year: summer

Comparison with "STAR" Data: rather frequent (average of nearest three hours - 3.2%).

### 3.3.4.6 Nederland - 3/7/73

Solar Insolation: moderately high solar altitude (55°); moderately high solar radiation (index 3); cloud cover signicant (7/10).

Temperature: average (66°)

Sea Level Pressure: very weak gradient

Wind Speed: very light (3 mph)

Wind Direction Range: calm to steady

Time of Day: late morning to afternoon (1100 and 1200)

Season of Year: late winter

### 3.3.4.7 San Antonio - 8/29/71

Solar Insolation; high solar altitude (69°); high solar radiation (index 4); no cloud cover through noon, becoming partly cloudy (more than 5/10) thereafter.

Temperature: high (89°)

Sea Level Pressure: weak to moderate anti-cyclonic curvature

Wind Speed: moderate (9 mph)

Wind Direction Range: extremely variable

Time of Day: afternoon (1600 and 1700)

Season of Year: summer

Comparison with "STAR" Data: average frequency (average of nearest three hours - 0.9%).

### 3.3.5 Summary of Meteorological Analysis

As discussed in section 3.3.3.1, the data analysis showed that the occurrence of high ambient ozone is associated with a characteristic meteorology. In section 3.3.3.2, it was further pointed out that the meteorology associated with high ozone measurements does not represent an unusual event and should be expected to reoccur.

Section 3.3.4 presented an analysis of the data associated with the basis of the control plan. By comparing this section with the general findings of section 3.3.3.1, it can be seen that these key data points fit the expected meteorology extremely well. In fact, all six parameters fit the expected values in Corpus Christi, Dallas, El Paso, Houston, and San Antonio. The Nederland data with regard to season of year and temperature do not meet the expected criteria. Regarding the Austin case, only half the parameters fit. Although the May 7, 1973 Austin event included unusual wind speed and pressure curvature, the preceeding four days all exceeded the ozone standard and all exhibited an anti-cyclonic pressure influence with more moderate wind speeds.

It was also shown in section 3.3.4 that the meteorology associated with the key ozone data occurs rather frequently in most cases. Thus, it is seen that the key ozone data do not represent an unusual meteorological event and the meteorology is expected to reoccur.

Finally, in answering the second question posed in section 3.0, it can be said that the ozone values, from a meteorological standpoint, are representative and are not anomalies.

## Section 3 References

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3-3 R. L. Larsen, A Mathematical Model for Relating Air Quality Measurements to Air Quality Standards, Publ AP-89, U.S. Environmental Protection Agency, Research Triangle Park, N.C., 1971.

3-4 R. I. Larsen, "An air quality data analysis system for interrelating effects standards, and needed source reductions," J. Air Poll. Control Assoc. 23:933 (1973).

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# 4.0 HYDROCARBON/PHOTOCHEMICAL OXIDANT MODEL

## 4.1 Available Models

In order to calculate the necessary emission reductions to attain ambient air quality standards, a model must be developed which defines the relationship between emissions and air quality and which adequately accounts for other parameters affecting air quality. Several procedures are available for estimating oxidant air quality based on changes in emissions and atmospheric dispersion of emissions. The complexity and sophistication of these procedures range from the few simple calculations of the linear rollback model that may be made manually, to thousands of calculations that require a computer for the complex models involving photochemistry and meteorology. The following is a discussion of atmospheric simulation models which may be used to predict ambient oxidant ($O_3$) concentrations based on emissions. Six models are discussed, in order of increasing complexity.

### 4.1.1. Linear Rollback

Linear rollback assumes that changes in ambient oxidant concentration levels are directly proportional to changes in total emissions. If the existing spatial and temporal distributions of emissions remain constant, this is a reasonable assumption (Ref. 4-1). The effects of meteorology on ambient concentrations are included implicitly in the technique by the dependence on ambient concentrations. For long time periods or for worst case values, this lack of explicit dependence on meteorology is not critical (Ref. 4-2). Advantages of the linear rollback model are that it is simple to use, it does not require extensive input data, and it's theoretical basis is readily understood.

### 4.1.2. Nonlinear Rollback

An alternate approach to the application of rollback to photochemical oxidants is a consideration that oxidant concentrations are related to ambient concentrations of both hydrocarbons and oxides of nitrogen in a nonlinear fashion. Nonlinear or modified rollback attempts to account for this effect through an empirically derived relationship between maximum daily 1-hour average oxidant concentrations and 6 to 9 a.m. average concentrations of non-methane hydrocarbons. Hydrocarbon concentrations are then assumed to depend linearly on emissions, so that a relationship between changes in hydrocarbon emissions and oxidant concentrations is achieved. One form of this relationship is the Appendix J curve of the EPA regulations (Ref. 4-3), which is based on the maximum observed relationship between hydrocarbons and oxidant concentrations for selected cities in the United States.

Such curves have also been developed which are specific to a city. These specific city relationships are an improvement for the individual locations to which they are applied since other curves in the literature are composites of data and are based on data taken before the EPA reference method for oxidants was defined.

It may well be that the Appendix J general relationship may apply in some Texas cities, but such data has not been compiled to date, and could differ in each urban area. Also, oxidant levels in some Texas cities are above the limits of the Appendix J curve. Extrapolation to these high oxidant levels would require reductions in hydrocarbons of greater than 100 percent. Clearly, Appendix J is not appropriate for these Texas cities.

### 4.1.3. Gifford - Hanna Photochemical Model

The Gifford-Hanna model is basically a "box model" in which average pollutant concentrations within the box are taken to be proportional to the ratio of the average area source strength to the wind speed. For purposes of chemical kinetics calculations, the pollutant concentrations are assumed to be uniform within the volume defined by the area of the region and the mixing depth. This technique includes the assumption that predicted $O_3$ concentrations are directly proportional to the predicted concentration ratios of $NO_2$ to NO, but does not allow for dependence on hydrocarbons.

Although this model may be useful in predicting trends in $O_3$ concentrations, it has to date predicted maximum $O_3$ values which compare poorly with actual measured values.

### 4.1.4. Reactive Environmental Simulation Model (REM)

The REM and DIFKIN (described in the following section) models are trajectory models, based on a Lagrangian or moving coordinate system. Both chemical and meteorological inputs are complex and extensive with a resultant large computer requirement.

The REM model has spatial and temporal detail far in excess of any of the models considered thus far. However, to date, REM has only been tested in Los Angeles. The results of that test show that $O_3$ prediction is within a factor of 2, in 75% of the comparisons.

### 4.1.5. Diffusion Kinetics Model (DIFKIN)

As in the case of REM, DIFKIN calculates the trajectory of an air parcel across an emission grid network and determines time dependent concentrations of reactive pollutants. Unlike REM, DIFKIN solves for turbulent diffusion in the vertical direction.

Because DIFKIN ignores horizontal diffusion, the model is probably more applicable to regions with only small emission gradients between adjacent grid elements. This effect may cause an error of about 40% under large gradient conditions (Ref. 4-1). It should be noted that this may be an important factor when considering emissions from large stationary sources and industrial areas which are large sources of photochemicals precursors, such as in the Gulf Coast area of Texas. Further, neglect of the vertical wind shear, inherent in trajectory models, may introduce errors of over prediction of 50% or greater (Ref. 4-5).

DIFKIN has been tested with reasonable success in Los Angeles, San Francisco, and Denver. However, the model must still be considered in the development stage.

### 4.1.6. Systems Applications Inc (SAI)

This model uses a finite difference technique over a grid of area sources to solve the classical equations of conservation of mass, which include local change, advection, diffusion, and photochemical reaction of emissions.

Application of this model to a given location is made difficult by the fact that some aspects of the program are quite specific to Los Angeles. A recent study (Ref. 4-5) concluded that in spite of the fact that the SAI model is an excellent research tool, the long running times and extensive data requirements make it difficult to use the model for analysis of different oxidant strategies without a considerable investment in time and manpower.

Although this model is one of the better photochemical models currently available, the reliability of the model has not been thoroughly examined (Ref. 4-2).

### 4.1.7. Conclusion

As in the previous oxidant plant, EPA has chosen to use the linear rollback model to relate hydrocarbon emission to photochemical oxidant air quality. The other simplified modeling technique, nonlinear rollback using Appendix J curve in 40 CFR 51, was not used in Texas since it could not be applied in all areas.

The more complex computer modeling techniques Gifford-Hanna, REM, DIFKIN, and SAI were also not used since their reliability in predicting oxidant levels ha not yet been demonstrated. In addition, these methods are very complicated and time-consuming, and require vast amounts of input data that are not generally available for Texas areas.

## 4.2 Limitations of Linear Rollback Model

Although linear rollback is considered the best modeling method for oxidants currently available due to its simplicity, uniformity in application, and understandable basis, the model does have some limitations in predicting maximum yearly oxidant levels based on changes in hydrocarbon emissions. These limitations as well as some limitations applicable to all present modeling techniques are as follows:

1. The first limitation is that the effects of meteorology on predicted ambient concentrations are not explicitly accounted for in the linear model. This limitation, however, is more than offset by the fact that the model uses worst case measured concentrations and therefore implicitly includes the effects of worst case meteorology on ambient concentrations.

2. Another limitation of the linear model is that the model does not account for the differences in photochemical reaction processes that can vary with the specific amounts and types of oxidant precursors in an area's atmosphere. Again, this effect is minimized by the fact that yearly worst case ambient measurements are used for each area in the model. A refinement to the model application in Texas that further minimizes the effects of different oxidant precursor breakdowns from area to area is that only reactive hydrocarbon inventories compiled for each area are used for rollback calculations.

3. Another limitation is that the linear rollback model does not have a rigorously defined area of influence for the

locations of oxidant precursor sources. The model assumes that all hydrocarbon emissions in the chosen model area cause the ambient oxidant value used for rollback purposes and that this oxidant value is typical of what could be expected everywhere in the modeling area. Thus if a modeling area is chosen that includes both the major populated and industrialized urban counties, (in which the only air quality measurements are usually taken), and also includes the surrounding non-urban counties, (with much lower emissions), the high oxidant values measured in the urban counties are assumed to be possible in the surrounding non-urban counties also. Similarly, the emissions from the non-urban areas are assumed to be contributing to the high oxidant value measured in the urban area.

The geographical extent of this urban/non-urban interaction is not clearly defined, and the extent of the modeling area is a judgement based on the emission air quality, meteorological, and geographical data available. There is much evidence from other areas than Texas to suggest that such short-range transport of oxidants and/or their precursors do occur and that values of oxidants as great as or higher than observed in the urban counties can occur in the non-urban counties also (Ref 4-6). The oxidants in these non-urban areas are due to both the transported oxidants and precursors from the urban areas and also due to the emissions in the immediate non-urban areas. Emission controls in both areas are therefore appropriate to ensure oxidant reductions in both non-urban and urban counties. Depending on the wind directions, the emissions in the surrounding non-urban areas can also contribute to the measured oxidant problem in the urban areas and controls can reduce the problems in both areas. Either by obtaining rural oxidant data in the non-urban areas around the Texas urban areas or by evaluating the potential non-urban oxidant problems and transport (rural emissions, typical meteorology, and distance to the metropolitan areas), the geographic limits of the model areas can be judiciously chosen to minimize the effects of this model limitation.

4. Another limitation to oxidant models is that the effects of long-range transport of oxidants and/or oxidant precursors are not included. EPA is continuing to evaluate the effects of long-range oxidant transport on the levels observed in both urban and rural locations, but at present the effects are not completely known and have not been quantified. Present information indicates, however, that during the days with meteorological conditions characterized by stagnant high pressure systems, the same conditions during which the highest oxidant values are observed, the oxidant problem is primarily attributed to those mobile and stationary source emissions generated with the local area itself (Ref. 4-6). The effects of long-range transport would therefore be minimizied in the proportional model, since the worst case, episode oxidant values are generally used.

5. The last limitation of oxidant models to be discussed is that there is no contribution of emissions of oxidants or their

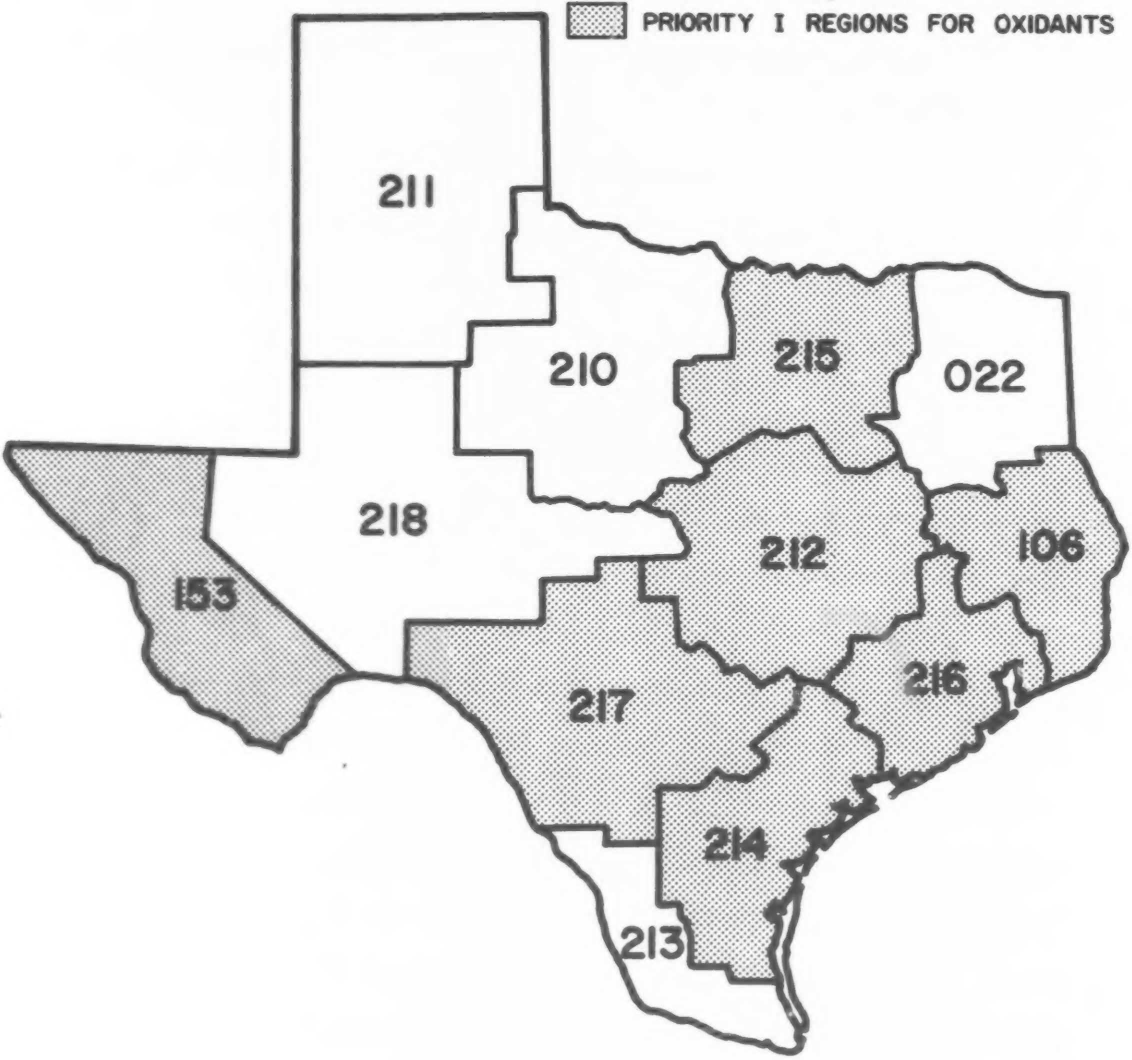
precursors from natural sources included. In general, EPA studies to date indicate that manmade emissions are the predominant source of the highest levels of oxidant observed and not naturally occurring sources of oxidants or their precursors (Ref. 4-6). Therefore the assumption that the naturally occurring sources are zero is considered to have a small effect on the overall oxidant/hydrocarbon modeling in a particular area.

Although the proportional rollback model does have limitations for oxidant projections as discussed above, these limitations can be minimized and are not so restrictive to make its use as a basis for developing oxidant control strategies inappropriate.

### 4.3 Texas Modeling Areas

One of the steps in using the linear rollback model is to define the extent of modeling area to be used. In the original plan, EPA chose as the modeling area the entire Air Quality Control Regions (AQCRs) for the areas of concern. The seven AQCRs of interest in Texas (each classified in 40 CFR 52.2271 as being Priority I regions for photochemical oxidants) are shown on Figure 4-1. Subsequent to the original plan development it became clear, however, that in several of the regions there was a low probability of significant interaction of the high oxidant levels and emissions in the urban areas with some of the outlying non-urban areas within the same AQCR. Extreme examples of such situations are the interactions between El Paso and Brewster

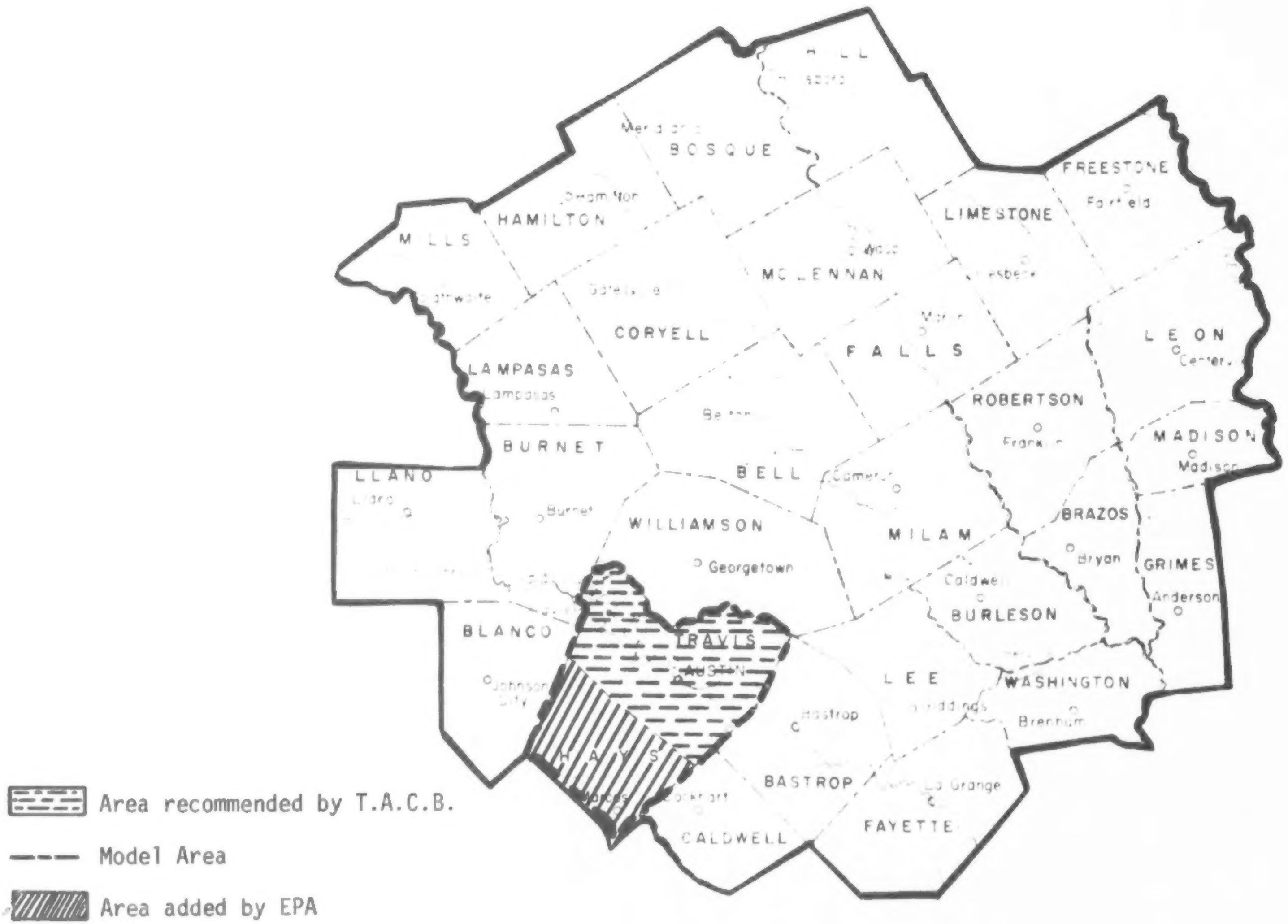
Figure 4-1


▨ PRIORITY I REGIONS FOR OXIDANTS
211
210
215
022
218
212
106
153
216
217
214
213

counties in AQCR 153 (separated by almost 200 miles), and between Bexar (San Antonio) and Val Verde counties in AQCR 217 (separated by almost 150 miles).

In order to improve the modeling technique in the revised control strategy development, the modeling areas were redefined and only those counties that had measured oxidant problems, or that were judged to be contributing to that measured oxidant problem, or that were judged as having a potential oxidant problem resulting from short-range transport were included. Figures 4-2 through 4-8 show the seven AQCRs and the model areas chosen for the revised strategy development. In general, the model areas chosen by EPA agree with the areas assumed by the TACB in reference 4-7. There were some small exceptions, however, in the Austin, San Antonio, Corpus Christi, and Beaumont areas. In these areas, EPA added one or two adjacent counties to the counties chosen by the TACB. Added in each case were the remaining counties in the Standard Metropolitan Statistical Area (SMSA) for the particular area of concern. These were determined to have the greatest potential for short-range transport and interaction with oxidants and precursor emissions from the adjacent counties. SMSAs, also exhibit the highest concentrations of population and industry and are generally the places with existing air quality problems.

Two sub-regions not included in the chosen modeling areas are the Waco area in AQCR 212 and the Victoria area in AQCR 214. Based on their hydrocarbon inventories these sub-regions appeared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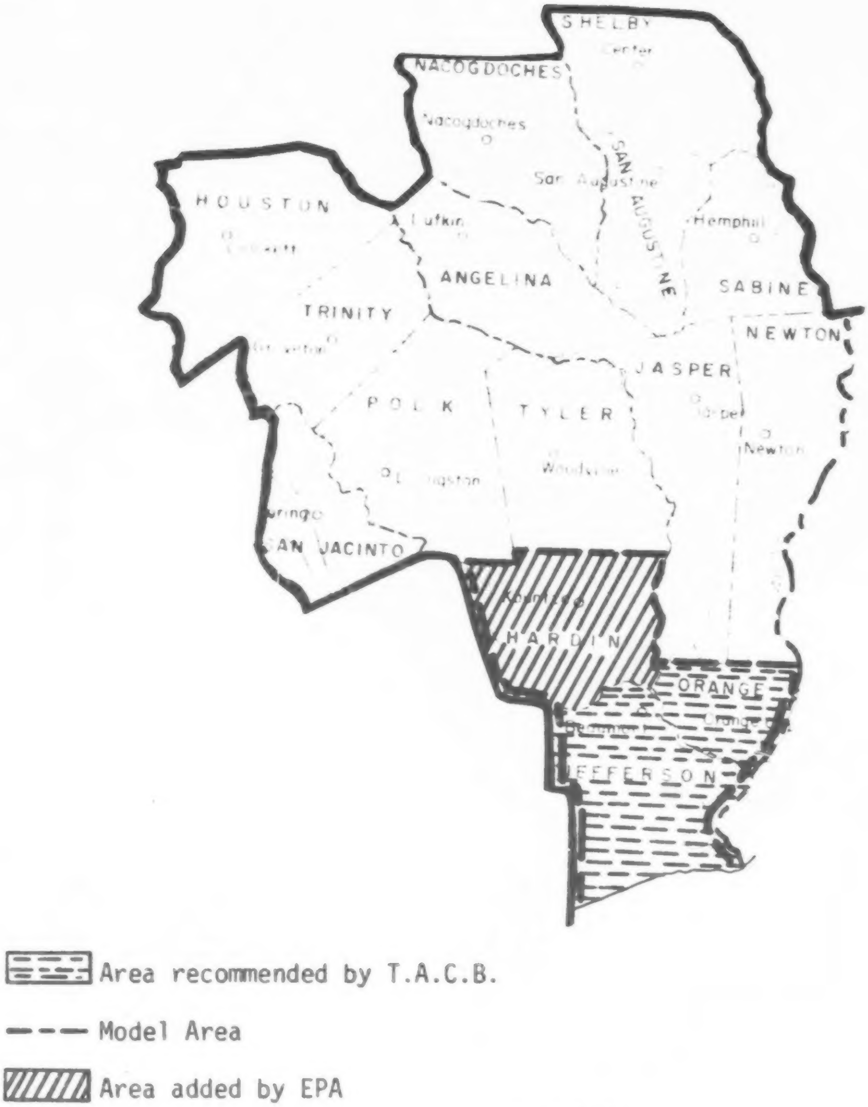
HAMILTON
MILLS
MC LENNAN
LIMESTONE
FREESTONE
Fairfield
CORYELL
FALLS
LEON
Center
LAMPASAS
Lampasas
ROBERTSON
Franklin
MADISON
Madison
BURNET
Burnet
BELL
Belton
LLANO
Llano
WILLIAMSON
Georgetown
MILAM
Cameron
BRAZOS
Bryan
GRIMES
Anderson
Caldwell
BURLESON
BLANCO
Johnson City
TRAVIS
Austin
HAYS
LEE
Giddings
WASHINGTON
Brenham
Bastrop
BASTROP
Lockhart
CALDWELL
La Grange
FAYETTE
Area recommended by T.A.C.B.
Model Area
Area added by EPA

Model Area

AQCR-212 (Austin Area)

Figure 4-2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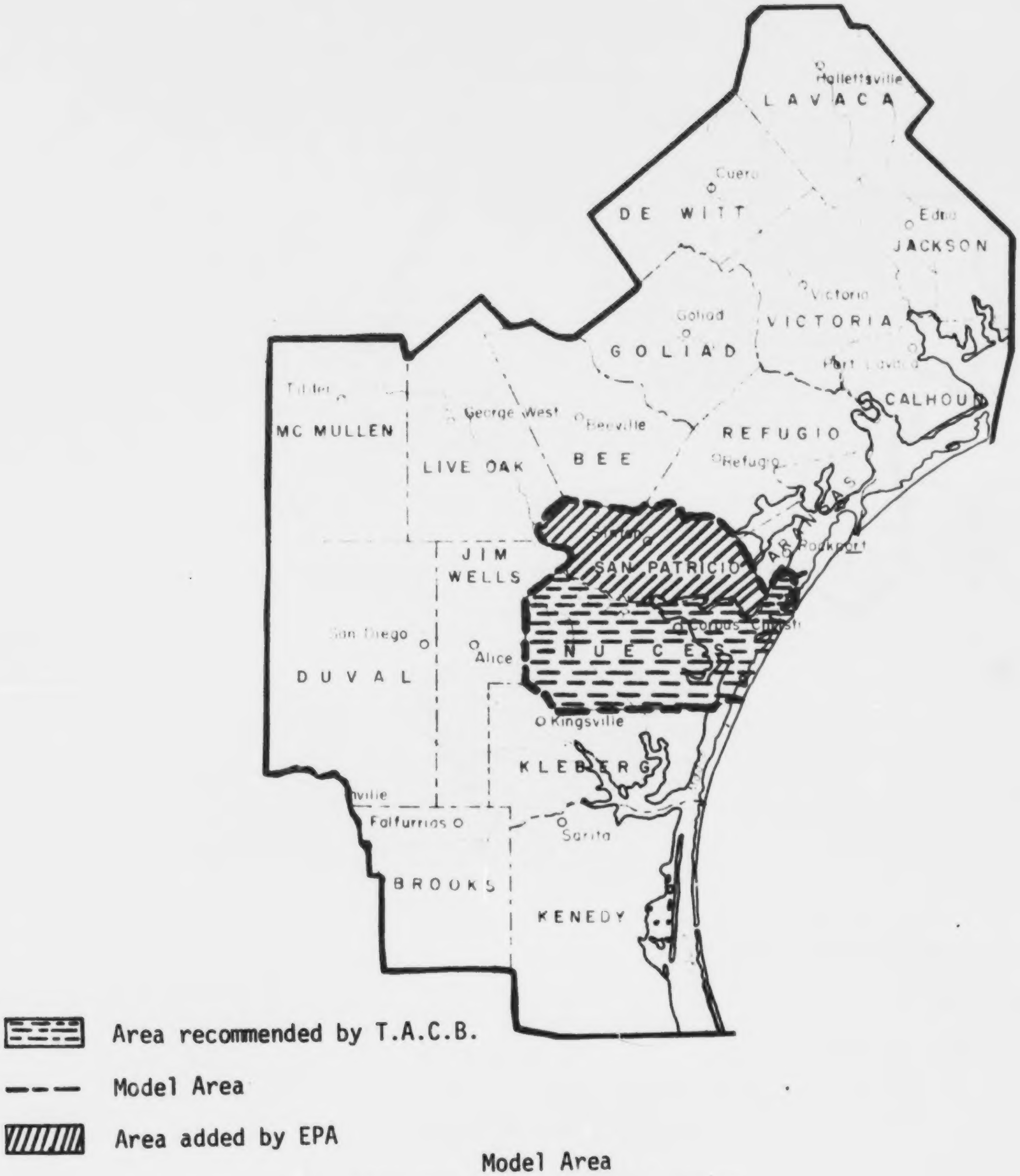
SABINE
TRINITY
Groveton
NEWTON
JASPER
Jasper
POLK
TYLER
Newton
Livingston
Woodville
Coldspring
SAN JACINTO
Kountze
HARDIN
ORANGE
Beaumont
Orange
JEFFERSON
Area recommended by T.A.C.B.
Model Area
Area added by EPA

Model Area

AQCR-106 (Beaumont-Port Arthur Area)

Figure 4-3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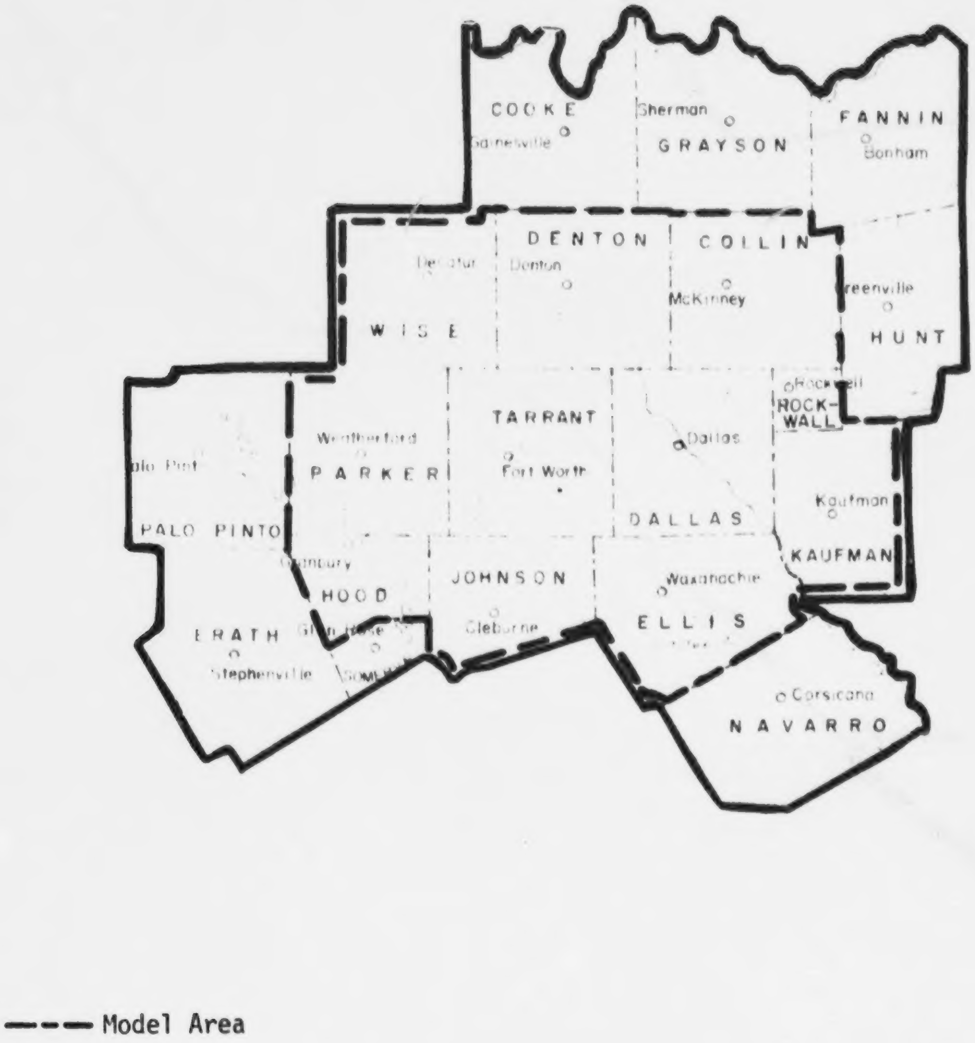
Cuero
DE WITT
Edna
JACKSON
Victoria
VICTORIA
Goliad
GOLIAD
Port Lavaca
CALHOUN
Tilden
MC MULLEN
George West
Beeville
LIVE OAK
BEE
REFUGIO
Refugio
ARANSAS
Rockport
Sinton
SAN PATRICIO
JIM WELLS
San Diego
Alice
Corpus Christi
DUVAL
NUECES
Kingsville
KLEBERG
Falfurrias
Sarita
BROOKS
KENEDY
▤ Area recommended by T.A.C.B.
--- Model Area
▨ Area added by EPA

Model Area
AQCR-214 (Corpus Christi Area)

Figure 4-4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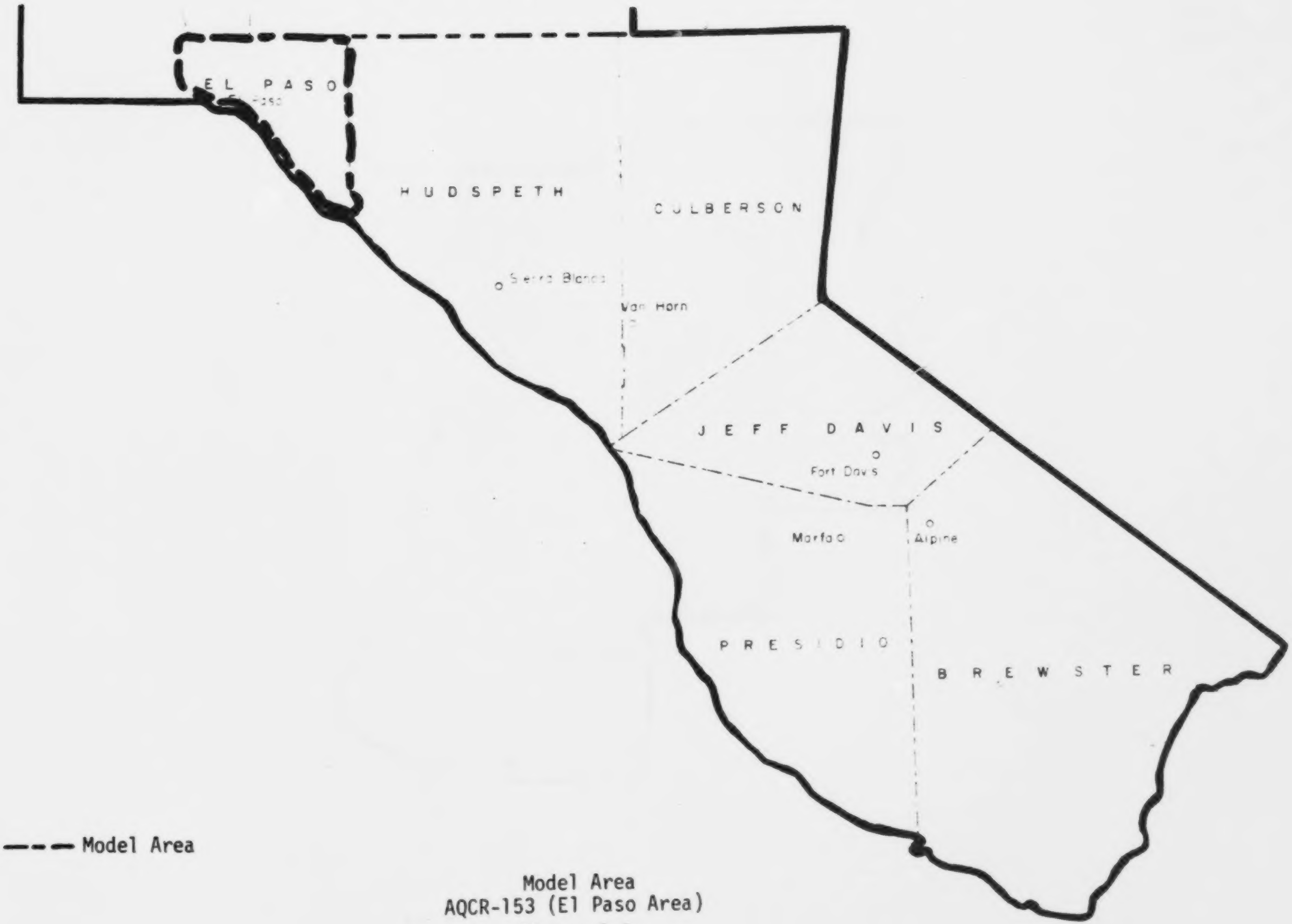
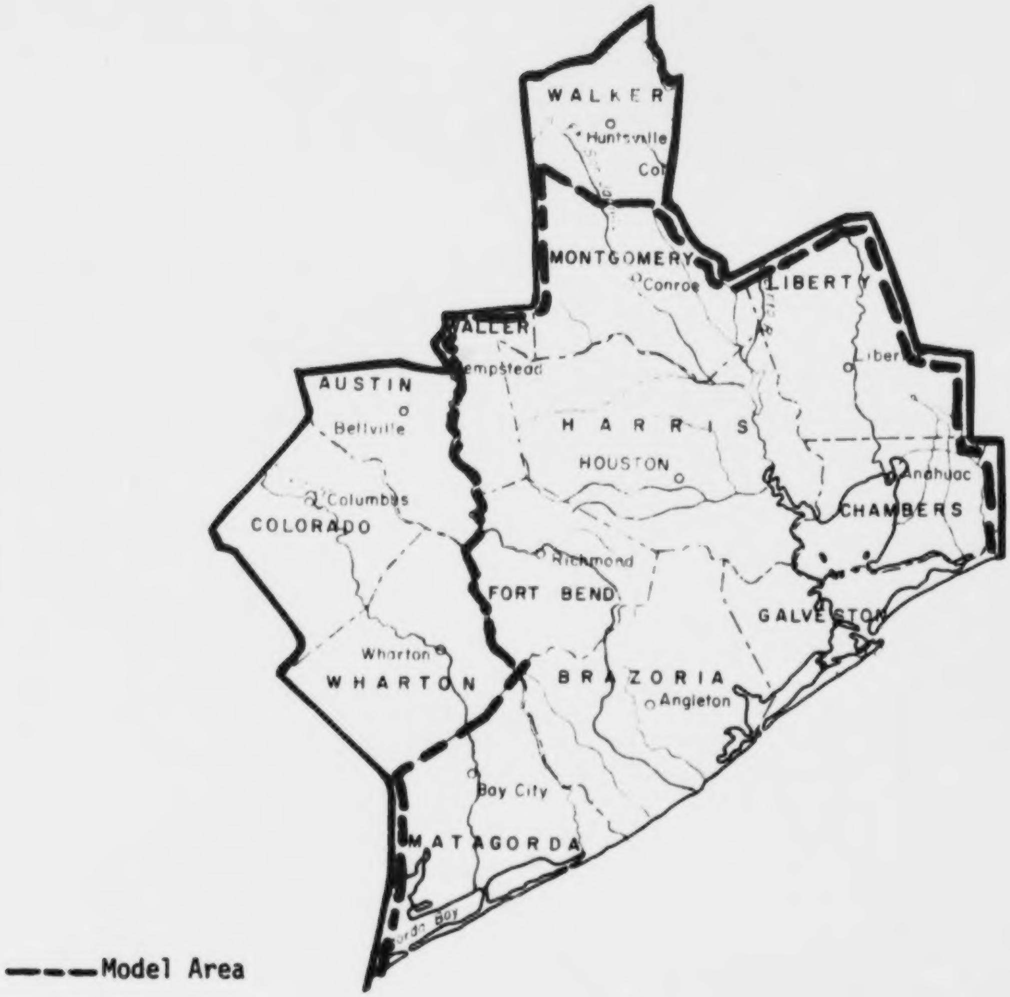
Sherman
GRAYSON
FANNIN
Bonham
DENTON
COLLIN
Decatur
Denton
McKinney
Greenville
WISE
HUNT
Rockwall
ROCK-WALL
TARRANT
Weatherford
Dallas
Palo Pinto
PARKER
Fort Worth
Kaufman
PALO PINTO
DALLAS
Granbury
KAUFMAN
JOHNSON
HOOD
Waxahachie
ERATH
Glen Rose
Cleburne
ELLIS
Stephenville
Corsicana
NAVARRO
Model Area

Model Area
AQCR-215 (Dallas-Fort Worth Area)

Figure 4-5


EL PASO
El Paso
HUDSPETH
CULBERSON
Sierra Blanca
Van Horn
JEFF DAVIS
Fort Davis
Marfa
Alpine
PRESIDIO
BREWSTER
Model Area

Model Area
AQCR-153 (El Paso Area)
Figure 4-6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MONTGOMERY
Conroe
LIBERTY
Liber
WALLER
Hempstead
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Bellville
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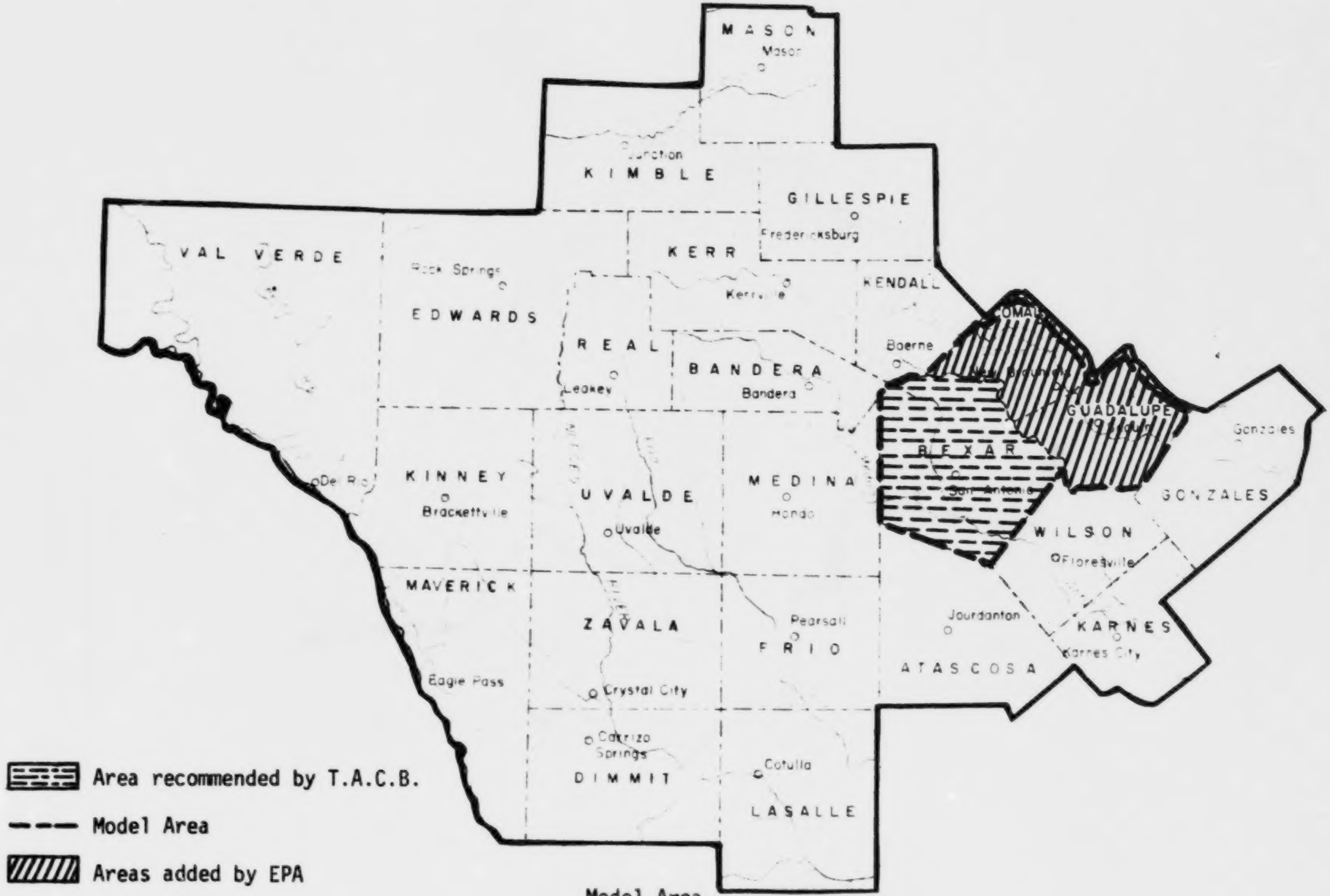
HOUSTON
Anahuac
CHAMBERS
Columbus
COLORADO
Richmond
FORT BEND
GALVESTON
Wharton
WHARTON
BRAZORIA
Angleton
Bay City
MATAGORDA
Bay
Model Area

Model Area
AQCR-216 (Houston-Galveston Area)

Figure 4-7


MASON
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Junction
GILLESPIE
Fredericksburg
VAL VERDE
KERR
Kerrville
KENDALL
Boerne
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REAL
Leakey
BANDERA
Bandera
COMAL
New Braunfels
GUADALUPE
Seguin
Gonzales
GONZALES
BEXAR
San Antonio
KINNEY
Brackettville
Del Rio
UVALDE
Uvalde
MEDINA
Hondo
WILSON
Floresville
MAVERICK
Eagle Pass
ZAVALA
Crystal City
FRIO
Pearsall
Jourdanton
ATASCOSA
KARNES
Karnes City
Carrizo Springs
DIMMIT
Cotulla
LASALLE
Area recommended by T.A.C.B.
Model Area
Areas added by EPA

Model Area
AQCR-217 (San Antonio Area)
Figure 4-8

to have a high probability of having oxidant problems. Due to the facts that there was no ambient air quality data for these two sub-regions and that there was not a clear interaction of these sub-regions with the identified problem areas in the AQCRs (Austin and Corpus Christi), they were excluded from the modeling area. Air quality monitoring data taken in the future in these two sub-regions as well as other Texas urban areas may identify more problems and necessitate further changes to the oxidant control strategy.

## 4.4 Emission Reduction Required

Using the proportional rollback model and the yearly second highest ozone levels observed in the regions, the percent hydrocarbon reductions required to meet the standard of 0.08 ppm are presented in Table 4-1. The percent reductions are calculated as follows:

$$\% \text{ reduction} = \frac{O - S}{O} \times 100\%$$

where O = observed second high yearly ozone value in the baseline year

S = the oxidant standard of 0.08 ppm

In general, the baseline year chosen is the year between 1971 and 1974 that the largest second high yearly ozone value was observed. Only in the Houston area is there an exception to this general situation in that the baseline year chosen is 1974 while the largest second high yearly ozone value was observed in 1972. The baseline years were all chosen to be the worst combination of

## Table 4-1 - Hydrocarbon Reduction Requirements

| Area | Baseline Year | 2nd High Values (ppm) | % Reduction |
|---|---|---|---|
| Austin (AQCR 212) | 1973 | .160 | 50 |
| Beaumont (AQCR 106) | 1973 | .325 | 75 |
| Corpus Christi (AQCR 214) | 1971 | .184 | 57 |
| Dallas/Ft. Worth (AQCR 215) | 1974 | .187 | 57 |
| El Paso (AQCR 153) | 1974 | .130 | 38 |
| Houston (AQCR 216) | 1974 | .234 | 66 |
| San Antonio (AQCR 217) | 1971 | .145 | 45 |

both the baseline year air quality and the expected emission reduction from the baseline year to 1977. For all cases except Houston, the combination of air quality and emission reductions yielded a baseline year the same as the year when the largest second high ozone value was observed. For Houston the combination of air quality and expected emission reductions gave 1974 as the worst case baseline year even though the air quality value was lower than other years. This effect is shown in the inventory and reduction tables of reference 4-7 where the additional reduction required for the 1974 baseline year is clearly the greatest of the potential baseline years evaluated.

## Section 4 References

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# 5.0 DEVELOPMENT OF REACTIVE HYDROCARBON EMISSION INVENTORIES FOR TEXAS

## 5.1 Introduction

In its August 1974 decision on the Texas Oxidant Control Plan the U.S. Court of Appeals for the Fifth Circuit remanded to EPA for reconsideration the reactive hydrocarbon emission inventory for petroleum refineries in Texas and the reactivity factor (0.12) used by EPA to estimate the photochemically reactive portions of refinery emissions. In September 1974 EPA and the Texas Air Control Board (TACB) entered into a joint study to reevaluate the Texas reactive hydrocarbon emission inventory. It was agreed that a restudy of the entire emissions data base and not just the refinery reactivity factor, questioned by the court, should be performed to ensure that the entire inventory for the Texas Oxidant Plan is computed on a consistent basis.

The basic ground rules established for development of the revised hydrocarbon emission inventory were as follows:

1. The entire inventory for stationary point sources, area sources, and mobile sources for the baseline year would be redone in the Dallas-Fort Worth, Austin, San Antonio, Houston-Galveston, Beaumont-Port Arthur, Corpus Christi, and El Paso Areas.

2. Stationary point source emissions would be based on the 1972 and 1973 Emission Inventory Questionnaires submitted to the TACB by industry.

3. Mobile source emissions would be computed based on the latest vehicle data available (1973 and 1974 data).

4. The inventory would include only photochemically reactive hydrocarbons (defined by joint agreement).

5. Specific information would be developed on the extent of industry controls in effect prior to implementation of TACB Regulation V to ensure that correct credit for emission reductions due to Regulation V would be made.

6. Projections of the expected emissions in 1977, 1980, and 1985 would be made, accounting for the effects of growth, TACB Regulations V and VI, and the Federal Motor Vehicle Control Program (FMVCP).

The TACB portion of the inventory reevaluation was conducted from September 1974 until March 1975. Results of the TACB effort are summarized in a preliminary report dated March 13, 1975 (Ref. 5-1). Sections 5.2 through 5.5 of this document describe how the revised inventory was developed and are based on the TACB report, supporting data supplied to EPA by TACB, and information developed by EPA during the course of the reevaluation effort. The resulting projected inventories for 1977, 1980, and 1985 presented in Section 5.5 assume only the emission controls in existence now (TACB Reg. V [Control of Hydrocarbons from Existing Sources] and Reg. VI [Control of Emissions from New or Modified Sources] and the Federal Motor Vehicle Control Program) and do not include the effects of any additional controls. Possible additional controls are discussed in Section 6.0 and the proposed additional controls are discussed in Section 7.0.

## 5.2 Photochemical Reactivity

### 5.2.1. Basis

Reactivity as used in this control plan means the tendency of hydrocarbons and organic compounds to photochemically react with other atmospheric pollutants and contribute to the production of photochemical oxidants. The use of a reactive hydrocarbon inventory instead of a total or a nonmethane hydrocarbon inventory is a refinement of the proportional rollback model which is designed to make the predicted reactive hydrocarbon reductions resulting from the applied controls more representative of their actual effects on ambient air quality.

It should be noted, however, that the use of reactive inventories is just a modeling tool to better predict the effects on air quality and that the controls applied reduce all hydrocarbon emissions and not just reactive emissions. Very few hydrocarbons are truly nonreactive. There is evidence that control of all nonmethane hydrocarbons might prevent oxidant production many miles downwind from the source where the low reactive (or slow reacting) compounds have had time to react (Ref. 5-2). Based on the proportional modeling technique used in this plan, however, the highly reactive (or fast reacting) compounds are of greatest concern and are considered to have the predominant effect on the ambient air quality measured in the major Texas metropolitan areas under consideration. For this reason the reactivity approach was retained for the revised inventory development. Should ongoing studies show a different reduction model is more appropriate in the future, a recalculation may be necessary at a later date.

Hydrocarbons and other organics vary widely in reactivity depending on chemical composition and reaction conditions. Present scientific knowledge does not permit making precise measurements of the reactive emissions in a particular metropolitan area, but an approximation of the reactive emissions can be made by a careful study of the sources of emissions in a particular area. To do this, a list of individual compounds that are nonreactive (or slowly reacting) are removed from the total hydrocarbon emissions for each source in that area. This can be accomplished by obtaining individual breakdowns by compound for each source and eliminating the nonreactive compounds or by developing reactivity factors based on a typical compound breakdown for a particular type of source.

For this revised inventory development, the list of nonreactive compounds (Table 5-1) published as part of the original EPA plan for Texas in the Federal Register on November 6, 1973 (F.R. 30626) in Section 52.2292 was agreed upon and used by the TACB and the EPA. This list is almost identical to the EPA list given in Appendix B to 40 CFR Part 51 for guidance in developing state implementation plans.

Table 5-1

Non-Reactive Carbon Compounds

$C_1$-$C_5$ n-paraffins

saturated halogenated hydrocarbons

perchloroethylene

benzene

acetylene

acetone

cyclohexanone

ethyl acetate

diethylamine

isobutyl acetate

isopropyl alcohol

menthyl benzoate

2-nitropropane

phenyl acetate

triethylamine

### 5.2.2. Stationary Source Reactivity

The source breakdown by compound for industries could not come directly from the TACB industrial emission inventory questionnaire (sample shown in Appendix B), since it lists total hydrocarbons and some breakdown on combustion emissions, but no breakdown on the amounts of specific hydrocarbon compounds emitted. For this reason, a more detailed questionnaire specifically requesting information on breakdown of nonreactive and reactive hydrocarbons emitted was sent to all Texas industries with major hydrocarbon emissions (500 tons/year or greater). A sample questionnaire is included in Appendix C. In addition to responses to the supplemental questionnaire, various companies furnished detailed analyses for typical emissions from in-process streams and final products.

For petroleum refineries, average weight percentage values of reactive emissions (reactivity factors) from 23 in-process and product streams (Table 5-2) were developed based on the information available to the TACB (see Appendix D for additional breakdown of refinery emissions).

Table 5-2

Weight Percentage Factors for Refinery In-process and Product Streams

| Stream | Wt. Percent Reactive |
|---|---|
| Finished Gasoline | 59 |
| Crude Oil | 40 |
| Kerosene | 67 |
| Jet Fuel | 67 |
| Cat Cracker (CC) | |
| Lt. Gasoline | 93 |
| Hydroformate | 80 |
| Alkylate | |
| undebutanized | 65 |
| debutanized | 85 |
| depentanized | 100 |
| Platformate | 77 |
| Reformer Feed | 85 |
| Naptha Base Stock | 68 |

| | |
|---|---|
| Heavy C.C. Naphtha | |
| undebutanized | 60 |
| debutanized | 80 |
| Raffinate | 70 |
| BTX Feed | 80 |
| Distillate Fuel | |
| #2 Diesel | 70 |
| Heating Oil | 70 |
| Crude Heavy Slop | 67 |
| V.MEP Naphtha | 90 |
| Cat. cycle stock | |
| coker | |
| decant oil | 90 |
| cat. cracker feed | |
| Lt. cycle stock | 80 |
| Heavy Diesel | |
| Bunker C | |
| No. 6 Fuel Oil | 60 |

Based on the total hydrocarbon information obtained from the regular TACB industry questionnaire, the refinery factors were applied to obtain the reactive emission from each process in the refinery. For chemical plants, a similar process was applied using the list of nonreactive compound with the data supplied in both the regular and supplemental questionnaires on a process-by-process basis to determine the reactive portions of the emissions. For the smaller industrial sources with emissions less than 500 tons/year, either reactivity factors developed from similar large processes were used to estimate the reactive portions or the list of nonreactive compounds in Table 5-1 was applied to specific process emissions to eliminate nonreactive compounds from the inventory.

The resultant industry-wide inventories for refineries and chemical plants in Houston using this process turned out to be 61% and 57% reactive respectively as compared to an assumption of 12% reactive for refineries and 60% reactive for chemical plants used by the EPA in the previous plan. Taken alone, this relatively large increase in the petroleum refinery reactivity and small decrease in the chemical industry reactivity would tend to add more reactive emissions to industry; therefore, more reactive reductions would be obtained from industry due to Texas Regulation V and less reductions needed from other sources such as transportation. This did not turn out to be the case, since the added effects of little improvement in air quality and, as will be discussed in Section 5.3 through 5.7, the reductions that were credited to Regulation V and FMVCP were not nearly so large as estimated in the previous plan.

### 5.2.3. Mobile Source Reactivity

Reactivity factors were used to establish the reactive inventory for all mobile hydrocarbon sources. The factors used are based on a typical breakdown by compound from the source of emissions and application of the definition of nonreactive compounds give in Table 5-1 to establish the reactivity factor for the source. In most cases the reactivity factors are about the same as those used by the EPA and the TACB in the earlier plans. The reactivity factors used are given in Table 5-3.

Table 5-3 Mobile Source Reactivity Factors

| Mobile Source Type | Factor |
|---|---|
| Gasoline Vehicle Exhaust | 0.74 |
| Gasoline Vehicle Evaporative and Crankcase | 0.60 |
| Diesel Vehicle Exhaust | 0.90 |
| Aircraft | 0.90 |
| Other Transportation | 0.80 |

Vehicle reactivity data and breakdowns of emissions by compound that were taken from data presented in Reference 5-3, 5-4, and 5-5. Specific breakdowns for the last three categories were not readily available but the available information seems to support the relatively high factors chosen. Due to the small contribution from these three emission categories, no further adjustments were made.

### 5.2.4. Other Sources

For trade paints, all water-based paints were considered nonreactive and all oil-based paints were considered to be reactive. Reactive gasoline marketing emissions and ship/barge/tank car refinery loading emissions were calculated using the reactivity factors developed from petroleum refinery information and are listed in Table 5-2.

## 5.3 Stationary Source Inventory Development

### 5.3.1. Industiral Point Source

#### 5.3.1.1. Base Year 1972 Company Reported, Adjusted, and Reactive Inventories.

A detailed evaluation of the emission inventories for industrial point sources was made by the TACB on a source-by-source basis. The 1972 hydrocarbon inventory, which is based on information from questionnaires sent to individual industries, was used as the basic source document of emissions from existing industrial sources. Although the 1972 inventory is the source document, the 1973 industry questionnaires were used extensively by TACB in updating 1972 emissions known to exist in 1972 but not reported until 1973.

A blank questionnaire is included in Appendix B to illustrate the kinds of information requested by the TACB. The basic categories of hydrocarbon data obtained from the questionnaires and evaluated by the TACB are as follows:

1. Storage
    a. Type of Storage
        (1) Fixed Roof
        (2) Floating Roof
    b. Storage Tank Capacity
        (1) < 1,000 gallons
        (2) 1,000 - 50,000 gallons
        (3) > 50,000 gallons
    c. Vapor Pressure
        (1) < 1.5 psia
        (2) 1.5 - 11 psia
        (3) 11+ psia

2. Loading and Unloading Facilities
    a. Ships and Barges
    b. Cars and Trucks
3. Water Separators
4. Process Vents Not Flared
5. Fugitive and Miscellaneous Losses

Tank emissions comprise a major source of hydrocarbons emitted from Texas Gulf Coast petroleum processing industries. Individual product emissions were reported in the questionnaires on a tank-by-tank basis for storage and loading operations. TACB made detailed checks of company-reported emissions with values calculated by TACB using emission factors from EPA document AP-42 (Ref. 5-6). Factors from AP-42 were used with an adjustment for vapor pressure at typical Texas storage temperatures. The TACB calculated values were used rather than the company reported values when significant differences were found. TACB also adjusted the company-reported values by eliminating methane and other combustion emissions since these emissions are all considered to be non-reactive. The process emissions from point sources were as reported by the companies except when refineries failed to report emissions from processes known to TACB. In such cases the TACB used an appropriate emission factor from AP-42 and calculated the emissions based on the known operating rate for each process unit.

Emissions for ship and barge loading operations were also calculated by the TACB based on AP-42 emission factors, but the emissions from these sources have been recalculated by EPA based on more current emission data. The details of the ship and barge emission calculations are presented in Section 5.3.2.

Since the control strategy is based on reactive hydrocarbons, the TACB took the adjusted inventory for each company and eliminated the non-reactive compounds by the methods previously discussed in Section 5.2.2.

#### 5.3.1.2 Projections of Reactive Emissions to 1973, 1974, 1975, 1977, 1980, and 1985

Projections of emissions to years 1973, 1974, 1975, 1977, 1980, and 1985 were made by the TACB. These projections changed the 1972 base year point source emissions by including the effects of industrial growth and stationary source emission controls required by Texas Regulation V.

The TACB used EPA estimates for SMSA Indices of Productions for Selected Industries (Ref. 5-7) to project industrial growth for stationary point sources. An overall index was calculated from the actual industry indices and applied to the 1972 base year emission inventory total to project emissions in 1977, 1980, and 1985 for each Texas area of concern. For years between 1972 and 1977, actual growth of point source emissions was known to the TACB from construction and operating permits and these emission growth values were used to project the 1973, 1974, and 1975 emissions.

TACB Regulation V (Control of Air Pollution from Volatile Carbon Compounds) became effective in 1972; therefore, after that date, substantial hydrocarbon emission reductions from industrial stationary sources were assumed to occur within the counties covered. Growth after 1972 is controlled by TACB Regulation VI (Control of Air Pollution by Permits for New Construction or Modification) which requires best available control technology, and which, in general, is more restrictive than the requirements for existing facilities. Thus, growth in emissions after 1972 is at a lower rate than the normal production growth rate.

Regulation V, which applies to existing point sources in certain counties, has rules which reduce emissions from these point source categories. Regulation V requires compliance with the applicable rules by certain dates which were determined with the required attainment date in mind. The compliance schedules of the larger emitters were reviewed by the TACB and used to determine the date the resulting reductions occurred.

The expected percentage reduction in emissions assumed by the TACB by applying controls required by Regulation V rules for each source category are as follows:

| Category | % Reduction |
|---|---|
| Tank | |
| 1-50,000 gal. | 96 |
| > 50,000 gal. | 97 |
| Loading Facilities | 85 |
| Water Separators | 98 |
| Process Vents Not Flared | 98 |

The above reduction factors were applied to the existing point source emissions for base year 1972 based on the individual company compliance schedules in order to project the reductions due to Regulation V in years 1973 through 1985. It should be noted that in reviewing the point source inventories for petroleum refineries, the TACB found that many companies had already installed controls on large petroleum storage tanks by 1972, that the effects of these controls had already been included in the inventories, and that much of the reductions predicted by the TACB in their previous plan due to Regulation V (90% reduction assumed by the TACB in 1973 plan) would not be obtained due to previous control of the tanks. Due primarily to this effect, the reductions resulting from Regulation V decreased from 90% in the 1973 plan to about 56% based on the current information in the Houston area. Similar changes in the effectiveness of Regulation V were observed in all areas.

Appendix E contains the TACB worksheets on a county and company basis for the point source inventory. The worksheets include the 1972 base year company-reported emissions, 1972 TACB adjusted emissions, 1972 TACB estimated reactive emissions, and 1973-1985 projected emissions with the effects of Regulation V included.

### 5.3.2 Emissions from Ship and Barge Loading Operations

#### 5.3.2.1 Background

During the loading of petroleum products in tank ships and barges at terminals in the Houston, Beaumont, and Corpus Christi areas, significant amounts of hydrocarbons are emitted to the atmosphere through the tank vessel vents. Gasoline vapors are the principal reactive hydrocarbon emissions from such loadings due to the high volatility of gasoline and the large quantities of gasoline produced and shipped by the Texas Gulf Coast petroleum processing industries. Gasoline shipments in the Houston-Galveston area on ships and barges are the greatest of the three areas, and they amount to about 100 million barrels per year. The Beaumont area has the second largest quantity of gasoline shipments with about 60 million barrels/year, while the Corpus Christi area gasoline loadings amount to about 20 million barrels/year.

In order to calculate the amount of emissions from ship and barge loadings in Texas, an emission factor (i.e., the number of pounds of vapor emitted per volume of product loaded) typical of gasoline loading conditions found in Texas is necessary. By having such a factor and by knowing the volume of gasoline loaded, expected emissions during gasoline loading can be estimated. In addition to the gasoline emissions, emission factors for other products can be established by adjusting for the vapor pressure and molecular weight of the product loaded. Annual product loading volumes are not difficult to establish and are published in reference 5-8. In addition, industries have submitted to both the TACB and the EPA total product volumes by product and by vapor pressure that have been loaded at their terminals.

The emission factor for each loading will not be constant, however, but will depend on many variables including the concentration of hydrocarbon vapor in the tank before loading, the true vapor pressure of the product being loaded, loading rate, the geometry of the tank, and how full the tank is loaded. The difficulty in the ship and barge emissions calculations lies in obtaining emission factors which have been weighted to be representative of all the above variables.

In the initial control plan, TACB used an emission factor of 11 pounds/1000 gallons of gasoline loaded into ships and barges. This factor was obtained from the second edition of AP-42 (Ref. 5-6) and was the factor given for working losses from fixed roof storage tanks. There was no emission factor for ship and barge emissions included in this edition of AP-42. This factor was based on a 100% saturation for the fixed roof storage tanks.

In Supplement No. 1 to AP-42 (Ref. 5-9) emission factors for ship and barge loading and unloading operations were included and were used by the TACB to estimate emissions from ship and barges for the revised inventory. The factor used by the TACB from AP-42 was 2.9 pounds/1000 gallons loaded. The TACB adjusted this factor up to 4.0 pounds/1000 gallons to account for expected higher loading temperature and higher true vapor pressures in Texas. Although the emission factor used for the revised inventory from Supplement No. 1 was specifically for ship and barge loadings, there were still several uncertainties in the factor. First of all, the revised factor was based on a very limited data base taken in the late 1950's for loadings on a few ships. In fact, the document containing the data and correlation (Ref. 5-10) on which the factor was based states that the marine loading correlations were not based on sufficient data and that more testing was needed. Secondly, the factor did not take into account the amount of vapor existing in the tank before loading. Thirdly, the data supplied to the EPA by several Houston area oil refiners indicated that the value of 4.0 pounds (1000 gallons) may be high by at least a factor of two. Based on these uncertainties, the EPA requested by letter (Ref. 5-11) copies of emission data collected by industry in order to develop a gasoline emission factor for ship and barge loadings.

To date the EPA has received twenty (20) responses from oil or petrochemical companies containing ship and barge emission data. In most cases the data seems to support the contentions that the original factor used (11 lb/1000 gal.) was much too high and that the revised factor used (4.0 lb/1000 gal.) may also be somewhat high. It is not clear from the data, however, just what a truly typical factor should be. What is typical for one company with one mode of loading may not be true for another company with a somewhat different mode of operation, and may even vary for the time of the year due to seasonal vapor pressure changes in gasoline loaded. In order to obtain a truly representative emission factor, much more data gathered on a consistent basis would be necessary.

#### 5.3.2.2. EPA Ship and Barge Emission Estimate

In order to develop a revised ship and barge inventory on the best data available at this time, a new ship and barge emission factor was used by the EPA. The EPA used the data supplied by one oil company, Exxon, to be typical of all gasoline ship and barge loadings in Texas. The Exxon information was used since the company's

Baytown refinery conducts more ship and barge loadings than any other refinery in the area and since the company submitted a substantial base of data. Exxon developed an emission factor for gasoline of 2.1 pounds/1000 gallons loaded based on measured factor of 1.8 lb/1000 gal. for 65 ship loadings of gasoline and 3.8 lb/1000 gal. for 20 barge loadings of gasoline at the Exxon terminal in Baytown. Development of these factors along with data sheets was reported to the EPA in references 5-12 and 5-13. Pertinent sections of the Exxon information on development of their emission factor is included in Appendix F.

Subsequent to submittal of the emission factor, Exxon in reference 5-14 developed their own inventory of hydrocarbon emissions from all volatile hydrocarbon products for all companies conducting ship and barge loadings in the Houston-Galveston area. The Exxon inventory yielded an average emission factor of 2.01 lb/1000 gallons for emissions of all products loaded from petroleum refineries and 1.2 lb/1000 gallons for emissions of all products loaded from chemical plants. Using these two emission factors and assuming that they are typical of refinery and chemical plant loadings in Texas, EPA developed a new emissions inventory for ship and barge loadings in the Houston, Beaumont, and Corpus Christi areas.

For the new inventory, the volumes of products loaded reported by the companies for 1974 loadings in Houston in response to the reference 5-11 request by the EPA were used to the maximum extent possible. Since no company volume loading data was submitted directly to the EPA for the Corpus Christi or Beaumont areas, the volumes reported to the TACB in the 1972 emissions inventory questionnaire were used for refinery loadings in the Corpus Christi and Beaumont areas. The volumes used were as follows:

| | Refinery Loadings | Chemical Loadings |
|---|---|---|
| Houston-Galveston | 93.1 million BBL | 23.8 million BBL |
| Beaumont-Port Arthur | 64.0 | -- |
| Corpus Christi | 20.6 | -- |

These figures were checked against summaries on waterborne commerce given in reference 5-8. The comparison showed good agreement. For chemical loadings in Beaumont and Corpus Christi, the emissions calculated by TACB were reduced by the ratio of the Exxon to the TACB/AP-42 gasoline emission factors (2.1/4.0) since they were such a small portion of the emission relative to refineries.

For reactivity factors, as discussed in Section 5.2.2. the average point source factors for petroleum refineries of 0.61 and for chemical plants of 0.57 were used. Since ship and barge emissions are predominantly from gasoline loadings, the reactive emissions must be controlled by the reactivity factor of 0.59 for gasoline evaporative emissions. This factor was based on the industry breakdowns included in Appendix D.

Projections of growth for ship and barge emissions were based on the petroleum refining and chemical industry growth rates listed in reference 5-7. The factors used were as follows:

| Base Year to | 1977 | 1980 | 1985 |
|---|---|---|---|
| 1971 (Corpus Christi) | 1.139 | 1.252 | 1.426 |
| 1973 (Beaumont) | 1.100 | 1.211 | 1.378 |
| 1974 (Houston) | 1.085 | 1.193 | 1.358 |

For petroleum refinery and chemical plant, 1974 ship and barge emissions in Houston, the calculation went as follows:

Refinery

$(93.1 \times 10^6$ bbl/year)(42 gal/bbl)(2.01 lb/1000 gal)(ton/2000 lb) (.61) = 2,397 tons/year

Chemical

$(23.8 \times 10^6$ bbl/year)(42 gal/bbl)(2.01 lb/1000 gal)(ton/2000 lb) (.57) = 342 tons/yr.

Total 1974 ship and barge reactive emissions for the Houston area thus equaled 2,739 tons/year. Results for similar calculations for all three areas are summarized in Table 5-4.

Table 5-4

Ship and Barge Reactive Hydrocarbon Emissions (tons/yr)

| | Baseline Year | 1977 | 1980 | 1985 |
|---|---|---|---|---|
| Corpus Christi (1971 Baseline) | 553 | 630 | 692 | 789 |
| Beaumont (1973 Baseline) | 1,677 | 1,845 | 2,031 | 2,311 |
| Houston (1974 Baseline) | 2,739 | 2,972 | 3,268 | 3,720 |

Note: About 90% of the above emissions are due to gasoline loadings.

### 5.3.3. Emissions from Gasoline Marketing Operations

As service station storage tanks and automobile tanks are filled, the gasoline vapors are expelled by displacement to the atmosphere. In the metropolitan areas of Texas, these emissions can be quite significant due to the large density of vehicles and their fueling requirements. Marketing emissions that occur during loading operations for tank trucks at bulk terminals are not included in this gasoline inventory but have been separately accounted for in the point source estimates discussed in Section 5-3.

To calculate emissions from such operations, the TACB used emission factors developed by the EPA and published in Supplement No. 1 to AP-42 (Ref. 5-9). Based on their knowledge of the petroleum marketing industry in the State, the TACB assumed that for loading the service station storage tank 45% of the loadings would be splash fill, 45% would be submerged fill, and 10% would have vapor recovery equipment. The emission factors given in AP-42 are:

(1) 11.5 lb/1000 gal. - splash loading

(2) 7.3 lb/1000 gal. - submerged loading

(3) 0.8 lb/1000 gal. - vapor recovery loading

(4) 11.0 lb/1000 gal. - vehicle tank loading

(5) 0.67 lb/1000 gal. - spillage loss during loading

Based on the assumed percentage breakdown during loading and the above emission factors, TACB calculated the following net emission factor for gasoline marketing operations:

$$EF = (.45)(11.5 + 11.0 + .67) + (.45)(7.3 + 11.0 + .67) + (0.1) \times (0.8 + 11.0 + .67) = 20.2 \text{ lb/1000 gallons marketed.}$$

Using an average vehicle gasoline mileage of 13.3 miles per gallon and a reactivity factor of 0.6, the 20.2 lb/1000 gallons converts to a factor of .00046 tons of reactive carbon compounds emitted per 1000 vehicle miles. This factor, multiplied by the appropriate vehicle mileage (VMT) gives the emissions from this source for each area and year of concern. TACB assumed that half of the additional gasoline necessary for any increase in VMT is supplied from existing gasoline stations, and half from new stations. Since stations constructed after 1973 are subject to new source controls on gasoline storage (usually consisting of facilities for submerged loading), a smaller emission factor (.00036 tons of reactive carbon compounds/1000 vehicle miles) is applied to gasoline dispensed from these stations. Because of this adjustment the average emission factor varies from .00046 in 1972-73 to about .00044 in 1985. The emissions from gasoline marketing activities were computed for each county and year of concern as part of the overall vehicle emissions calculations described in Section 5.4. Results are summarized in the TACB worksheets contained in Appendix G.

### 5.3.4. Area Sources (Solvent Evaporation)

Various manufacturing and maintenance processes result in the evaporation into the atmosphere of reactive hydrocarbon solvents. These processes include manufacturing and architectural coating operations, drycleaning of garments, degreasing and cleaning of components, etc. The revised inventory prepared by the TACB specifically includes an estimate of solvent emissions from trade paints (architectural coatings), and drycleaning operations in Texas. The development of this inventory was the same as for the original 1973 Texas plan and is documented in reference 5-15. Emissions from these categories are relatively small and due to changes in the need for such processes the reactive emissions are decreasing with time.

Industrial solvent emissions such as manufacturing coatings and solvent degreasing have not been specifically identified in the TACB inventory, but significant sources should be included by industry in their submittals of point source inventory questionnaires, and are included in the point source emissions inventory totals contained in this document. The TACB did make an estimate of the amount of industrial degreasing emissions in order to calculate the possible effects of controls on degreasing operations. The estimates were made only for the three largest manufacturing areas, Dallas-Ft. Worth, San Antonio, and Houston. The TACB based the estimates on inquiries with solvent manufacturers and distributors in the State. The TACB worksheets for the degreasing estimate are included in Appendix H. The estimates discussed above are used for the revised inventory.

## 5.4 Mobile Sources

Emissions from mobile sources were completely recalculated by the TACB for the reexamination effort. In reference 5-1 the TACB discusses in detail how the recalculations were performed (applicable pages of reference 5-1 are included in Appendix I). Sources included in the mobile category are exhaust, crankcase, and evaporative emissions from both gasoline-powered and diesel-powered vehicles, aircraft emissions, and other transportation emissions (off-highway, railroads, and vessels).

By far the most important, due to the large number of vehicles in this category, are emissions from light-duty gasoline-powered vehicles. Emissions in this category average about 80% of the mobile emissions in the Texas areas evaluated in 1972. For this reason TACB went into the most detail in their evaluation of light-duty (LDV) emissions.

The LDV emission analysis performed for the reexamination was in general the same type of analysis as performed by the TACB and the EPA in 1973 for the original oxidant/hydrocarbon control plans (Refs. 5-15 and 5-16). The results of this analysis give projected LDV emissions for years 1971 through 2000 which include the effects of expected growth in the number of vehicles and emission reductions as a result of the Federal Motor Vehicle Control Program (FMVC). Differences between the original calculations and the reexamination calculation are as follows:

a. More current vehicle registration and vehicle miles traveled data that reflect the effects of the energy crisis are included.

b. Revised emission factors contained in Supplement No. 5 to AP-42 are included.

c. Revised emission factors to reflect the additional one-year extension granted auto manufacturers in June 1974 in meeting the 90% reduction (a reduction from 4.1 grams/mile in 1970 to 0.41 grams/mile in 1977) established by the 1970 Clean Air Act are included.

Including the effect of growth in the number of vehicles on the road, the TACB calculations show that the FMVCP obtains about 20% reduction from 1971 to 1977. These reductions are not nearly so great as the previous reductions of about 50% in the initial plan. This lower reduction is due primarily to the change in emission factors for evaporative emissions from controlled LDV. Based on more extensive measurements of evaporative emissions in 1973 from controlled vehicles, the evaporative emission factor ranged from 0.2 grams/mile to 1.76 grams/mile. This makes the evaporative hydrocarbon emissions for the 1977 model year and later model year vehicles about as large as the exhaust emissions, and is the primary cause of lower credited reductions to the FMVCP in the revised plan. EPA is presently working with the automobile manufactures to revise the test method for evaporative loses. This should result in better control for evaporative losses.

Normal engine deterioration from wear, etc., is included in the calculations and is determined from in-use vehicle testing performed by EPA. The assumption is also made that the control devices installed on new vehicles as part of the FMVCP remain installed and working properly on the vehicle throughout the life of the car. If this is not the case, as might occur with removal of control devices by owners or repairmen, or with poor maintenance, then even the 20% calculated reduction will not be realized and emissions from LDV will not decrease as rapidly as expected and could conceivably increase.

It should be noted that on March 5, 1975, the Administrator announced his decision to delay for one year (to 1978 model year vehicles) the requirement for 90% reductions in hydrocarbon and carbon monoxide exhaust emissions. In addition, the Administrator proposed that those statutory standards be further delayed until the 1982 model years. The effects of the one-year delay and the effects of the possible delay to 1982 have not been incorporated into the TACB emission calculations for LDV. The effects on calculated 1977 LDV emissions would not be significant, but vehicle exhaust emissions for 1980 and 1985 could increase 10 to 20% as a result of these delays.

## 5.5 Ciudad Juarez Emission Estimate

Since Ciudad Juarez and El Paso are adjacent to one another and share a common air shed, hydrocarbon emissions from Ciudad Juarez should be considered with the El Paso emissions in order to properly model the effects of hydrocarbon emissions on oxidant levels in El Paso. The TACB in Addendum 1 to reference 5-1 made an estimate of Ciudad Juarez hydrocarbon emissions by assuming the emissions for years 1972 through 1977 would be equal to the 1972 El Paso emissions. Based on additional information, the EPA made a similar estimate of Ciudad Juarez emissions for years 1974 through 1985. The assumptions used by the EPA are listed below:

1. Area sources and point source hydrocarbon emissions were assumed to be 1/2 that of El Paso in 1974 due to the expected fewer hydrocarbon-producing industries in Ciudad Juarez. These emissions were assumed to remain constant through 1985.

2. Gasoline marketing emissions were assumed to be 0.44 that of El Paso based on the ratio of numbers of vehicles in Ciudad Juarez and El Paso.

3. Light-duty gasoline vehicle emissions for Ciudad Juarez in 1974 were assumed to be 1.55 times the 1974 El Paso value. This factor was derived assuming that all Ciudad Juarez vehicle emissions were equal to typical levels for precontrolled vehicles (pre '68) in the U.S. plus 20% to account for less maintenance of Juarez vehicles. This value was then reduced by the ratio of the number of vehicles in the two cities. With typical pre-'68 exhaust emissions equal to 8.8 grams/mile and 1974 El Paso exhaust emissions equal to about 3.0 grams/mile, the factor was calculated as follows: $\frac{(8.8)(1.2)}{3.0} \times .44 = 1.55$.

Based on Mexico's emission control program (discussed in reference 5-17) it was assumed that controls would obtain similar percentage reductions as in El Paso for years 1977, 1980, and 1985.

4. Heavy-duty vehicle emissions were assumed to be 1/2 that of El Paso.

5. Diesel vehicle emissions were assumed to be equal to El Paso diesel emissions.

6. Aircraft emissions were assumed to be 5% of those in El Paso based on less scheduled commercial traffic and comparatively little military air traffic.

7. Other transportation emissions were assumed to be 0.44 as great as El Paso based on the ratio of vehicles in each area.

The emission inventory summaries in Section 5.6 include combined El Paso-Ciudad Juarez emissions based on the EPA estimate along with individual estimates for El Paso and Ciudad Juarez. Although values for Ciudad Juarez are based on several gross assumptions, the combined El Paso-Ciudad Juarez estimate is considered much more representative of the area emissions than the more accurate El Paso inventory if taken alone. The combined area estimate should allow a much better prediction of how controls developed and implemented in El Paso affect the oxidant levels in the El Paso area.

A detailed evaluation of Ciudad Juarez hydrocarbon emissions would better define the specific contributions of their emissions to the oxidant levels in El Paso and identify what possible international control strategies might be considered.

## 5.6 Emission Inventory Summaries

A summary of the reactive hydrocarbon emission inventories is presented in Tables 5-5 through 5-13. The projected emissions for years 1977, 1980, and 1985 reflect the anticipated emission levels with no controls beyond the TACB Stationary Source Regulations V (existing sources) and VI (new sources), and the Federal Motor Vehicle Control Program (FMVCP). In addition, the tables present the required emission reductions and allowable yearly emissions to meet the oxidant standard based on the reduction requirements established in Section 4.

As discussed in Section 4.3, the model area chosen by the EPA is slightly different from that chosen by the TACB in that emissions from five additional counties are included for modeling purposes. Based on the TACB worksheets supplied to the EPA the inventories in Tables 5-5 through 5-13 include the emissions from these additional counties and, therefore, differ slightly from the values reported by the TACB in reference 5-1.

In all Texas areas evaluated, the projected 1977, 1980, and 1985 inventories exceed the calculated allowable emissions necessary to attain the oxidant standard. Emissions exceeding allowable range from as little as 14% in 1985 for El Paso and as great as 134% in 1985 for Houston. It should be noted that the projected emissions for 1980 and 1985 are more uncertain than the 1977 projections. This increased uncertainty is due to the limited accuracy of specific area growth trends in industry and transportation, and also to possible changes in the FMVCP between 1977 and 1982.

## Table 5-5--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for Austin Area

| | 1973* tons/yr | 1977 tons/yr | 1980 tons/yr | 1985 tons/yr |
|---|---|---|---|---|
| **Stationary Sources** | | | | |
| Area (trade paints & drycleaning) | 632 | 423 | 374 | 328 |
| Point Sources | 1,921 | 897 | 897 | 983 |
| Ship & Barge | -- | -- | -- | -- |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 405 | 441 | 486 | 569 |
| Vehicle Tank Loading | 607 | 662 | 729 | 853 |
| | 3,565 | 2,423 | 2,486 | 2,733 |
| **Mobile Sources** | | | | |
| Gasoline Vehicles | | | | |
| LDV | 11,034 | 8,809 | 7,248 | 6,079 |
| HDV | 704 | 562 | 463 | 388 |
| Diesel Vehicles | 155 | 141 | 155 | 177 |
| Aircraft | 223 | 287 | 338 | 438 |
| Other Transportation | 977 | 1,010 | 1,045 | 1,137 |
| | 13,093 | 10,809 | 9,249 | 8,219 |
| Grand Totals | 16,658 | 13,232 | 11,735 | 10,952 |

Required Reduction = 50% x Baseline Inventory = 8,329 tons/year

Allowable Emissions = 8,329 tons/year

* Baseline Year

Austin Area Counties: Travis and Hays

## Table 5-6--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for Beaumont-Port Arthur Area

| | 1973*<br>tons/yr | 1977<br>tons/yr | 1980<br>tons/yr | 1985<br>tons/yr |
|---|---|---|---|---|
| **Stationary Sources** | | | | |
| Area (trade paints & drycleaning) | 685 | 469 | 420 | 377 |
| Point Sources | 160,404 | 48,028 | 48,828 | 50,376 |
| Ship & Barge | 1,677 | 1,845 | 2,031 | 2,311 |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 378 | 367 | 457 | 533 |
| Vehicle Tank Loading | 568 | 551 | 683 | 800 |
| | 163,712 | 51,260 | 52,419 | 54,397 |
| **Mobile Sources** | | | | |
| Gasoline Vehicles | | | | |
| LDV | 10,334 | 7,461 | 6,802 | 5,666 |
| HDV | 660 | 476 | 434 | 362 |
| Diesel Vehicles | 354 | 225 | 277 | 317 |
| Aircraft | 121 | 130 | 140 | 154 |
| Other Transportation | 1,735 | 1,736 | 1,736 | 1,736 |
| | 13,204 | 10,028 | 9,389 | 8,235 |
| Grand Totals | 176,916 | 61,288 | 61,808 | 62,632 |

Required Reduction = 75% x Baseline Inventory = 132,687 tons/year

Allowable Emissions = 44,229 tons/year

*Baseline Year

Beaumont-Port Arthur Area Counties: Hardin, Jefferson, and Orange

## Table 5-7--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for Corpus Christi Area

| | 1971* tons/yr | .1977 tons/yr | 1980 tons/yr | 1985 tons/yr |
|---|---|---|---|---|
| Stationary Sources | | | | |
| Area (trade paints & drycleaning) | 573 | 327 | 283 | 241 |
| Point Sources | 63,527 | 37,028 | 36,865 | 40,419 |
| Ship & Barge | 553 | 630 | 692 | 789 |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 270 | 330 | 365 | 427 |
| Vehicle Tank Loading | 404 | 496 | 547 | 641 |
| | 65,327 | 38,811 | 38,752 | 42,517 |
| Mobile Sources | | | | |
| Gasoline Vehicles | | | | |
| LDV | 8,934 | 6,857 | 5,583 | 4,598 |
| HDV | 570 | 438 | 356 | 294 |
| Diesel Vehicles | 63 | 76 | 82 | 94 |
| Aircraft | 2,767 | 2,641 | 2,659 | 2,697 |
| Other Transportation | 1,202 | 1,180 | 1,180 | 1,180 |
| | 13,536 | 11,192 | 9,860 | 8,863 |
| Grand Totals | 78,863 | 50,003 | 48,612 | 51,380 |

Required Reduction = 57% x Baseline Inventory = 44,952 tons/year

Allowable Emissions = 33,911 tons/year

*Baseline Year

Corpus Christi Area Counties: Nueces and San Patricio

## Table 5-8--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for Dallas/Fort Worth Area

| | 1974*<br>tons/yr | 1977<br>tons/yr | 1980<br>tons/yr | 1985<br>tons/yr |
|---|---|---|---|---|
| Stationary Sources | | | | |
| Area (trade paints & drycleaning) | 4,428 | 3,625 | 3,284 | 3,010 |
| Point Sources | 13,782 | 13,107 | 13,552 | 14,289 |
| Ship & Barge | -- | -- | -- | -- |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 2,714 | 3,041 | 3,370 | 4,005 |
| Vehicle Tank Loading | 4,076 | 4,563 | 5,057 | 6,006 |
| | 25,000 | 24,336 | 25,263 | 27,310 |
| Mobile Sources | | | | |
| Gasoline Vehicles | | | | |
| LDV | 63,598 | 55,800 | 46,757 | 40,638 |
| HDV | 4,060 | 3,562 | 2,984 | 2,594 |
| Diesel Vehicles | 1,516 | 1,676 | 1,837 | 2,108 |
| Aircraft | 4,381 | 5,003 | 6,555 | 8,996 |
| Other Transportation | 6,746 | 7,238 | 7,667 | 8,719 |
| | 80,301 | 73,279 | 65,800 | 63,055 |
| Grand Totals | 105,301 | 97,615 | 91,063 | 90,365 |

Required Reduction = 57% x Baseline Inventory = 60,022 tons/year

Allowable Emissions = 45,279 tons/year

*Baseline Year

Dallas-Fort Worth Area Counties: Collin, Dallas, Denton, Ellis Hood, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise

### Table 5-9--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for El Paso Area (Juarez Not Included)

| Stationary Sources | 1974*<br>tons/yr | 1977<br>tons/yr | 1980<br>tons/yr | 1985<br>tons/yr |
|---|---|---|---|---|
| Area (trade paint & drycleaning) | 616 | 480 | 411 | 343 |
| Point Sources | 4,202 | 2,196 | 2,237 | 2,289 |
| Ship & Barge | -- | -- | -- | -- |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 300 | 336 | 373 | 443 |
| Vehicle Tank Loading | 450 | 504 | 559 | 665 |
| | 5,568 | 3,516 | 3,580 | 3,740 |
| **Transportation** | | | | |
| Gasoline Vehicles | | | | |
| LDV | 8,486 | 7,532 | 6,277 | 5,185 |
| HDV | 542 | 481 | 401 | 331 |
| Diesel Vehicles | 191 | 213 | 236 | 276 |
| Aircraft | 676 | 699 | 832 | 994 |
| Other Transportation | 737 | 808 | 743 | 762 |
| | 10,632 | 9,733 | 8,489 | 7,548 |
| Grand Totals | 16,200 | 13,249 | 12,069 | 11,288 |

Required Reduction = 38% x Baseline Inventory = 6,156 tons/year

Allowable Emissions = 10,044 tons/year

*Baseline Year

El Paso Area County (Juarez not included): El Paso

### Table 5-10--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for El Paso Area (Juarez Included)

| | 1974* tons/yr | 1977 tons/yr | 1980 tons/yr | 1985 tons/yr |
|---|---|---|---|---|
| **Stationary Sources** | | | | |
| Area (trade paints & drycleaning) | 924 | 788 | 719 | 651 |
| Point Sources | 6,404 | 4,398 | 4,439 | 4,491 |
| Ship & Barge | -- | -- | -- | -- |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 432 | 484 | 537 | 638 |
| Vehicle Tank Loading | 648 | 726 | 805 | 958 |
| | 8,408 | 6,396 | 6,500 | 6,738 |
| **Mobile Sources** | | | | |
| Gasoline Vehicles | | | | |
| LDV | 21,639 | 19,206 | 16,006 | 13,221 |
| HDV | 813 | 752 | 672 | 602 |
| Diesel Vehicles | 382 | 426 | 472 | 552 |
| Aircraft | 710 | 734 | 874 | 1,044 |
| Other Transportation | 1,061 | 1,164 | 1,070 | 1,097 |
| | 24,605 | 22,282 | 19,094 | 16,516 |
| Grand Totals | 33,013 | 28,678 | 25,594 | 23,254 |

Required Reduction = 38% x Baseline Inventory = 12,545 tons/year

Allowable Emissions = 20,468 tons/year

*Baseline Year

El Paso Area County (Juarez included): El Paso

Table 5-11--Reactive Hydrocarbon Emission Inventory Estimates in Juarez

| | 1974*<br>tons/yr | 1977<br>tons/yr | 1980<br>tons/yr | 1985<br>tons/yr |
|---|---|---|---|---|
| Stationary Sources | | | | |
| Area (1/2 El Paso in '72) | 308 | 308 | 308 | 308 |
| Point Sources (1/2 El Paso '74) | 2,202 | 2,202 | 2,202 | 2,202 |
| Ship & Barge | -- | -- | -- | -- |
| Gasoline Marketing | | | | |
| Storage Tank Loading (.44 x El Paso) | 132 | 148 | 164 | 195 |
| Vehicle Tank Loading (.44 x El Paso) | 198 | 222 | 246 | 293 |
| | 2,840 | 2,880 | 2,920 | 2,998 |
| Mobile Sources | | | | |
| Gasoline Vehicles | | | | |
| LDV (1.55 x El Paso | 13,153 | 11,674 | 9,729 | 8,036 |
| HDV (1/2 El Paso '74) | 271 | 271 | 271 | 271 |
| Diesel Vehicles (= to El Paso) | 191 | 213 | 236 | 276 |
| Aircraft (5% of El Paso) | 34 | 35 | 42 | 50 |
| Other Transportation (.44 x El Paso) | 324 | 356 | 327 | 335 |
| | 13,973 | 12,549 | 10,605 | 8,968 |
| Grand Totals | 16,813 | 15,429 | 13,525 | 11,966 |

*Baseline Year

## Table 5-12--Reactive Hydrocarbon Emission Inventory With FMVC and Existing Stationary Source Controls for Houston-Galveston Area

| | 1974*<br>tons/yr | 1977<br>tons/yr | 1980<br>tons/yr | 1985<br>tons/yr |
|---|---|---|---|---|
| **Stationary Sources** | | | | |
| Area (trade paint & drycleaning) | 4,065 | 3,299 | 2,962 | 2,676 |
| Point Sources | 215,302 | 139,887 | 152,157 | 175,047 |
| Ship & Barge | 2,739 | 2,972 | 3,268 | 3,720 |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 2,469 | 2,743 | 3,021 | 3,533 |
| Vehicle Tank Loading | 3,704 | 4,114 | 4,533 | 5,296 |
| | 228,279 | 153,015 | 165,941 | 190,272 |
| **Mobile Sources** | | | | |
| Gasoline Vehicles | | | | |
| LDV | 61,884 | 55,311 | 45,073 | 36,469 |
| HDV | 3,950 | 3,531 | 2,877 | 2,328 |
| Diesel Vehicles | 1,635 | 1,804 | 1,973 | 2,253 |
| Aircraft | 1,739 | 1,913 | 2,384 | 3,065 |
| Other Transportation | 7,009 | 7,351 | 7,712 | 8,682 |
| | 76,217 | 69,910 | 60,019 | 52,797 |
| Grand Totals | 304,496 | 222,925 | 225,960 | 243,069 |

Required Reduction = 66% x Baseline Inventory = 200,967 tons/year

Allowable Emissions = 103,529 tons/year

*Baseline Year

Houston-Galveston Area Counties: Brazoria, Chambers, Fort Bend, Galvest
Harris, Liberty, Matagorda, Montgomery, and Waller

## Table 5-13--Reactive Hydrocarbon Emission Inventory with FMVC and Existing Stationary Source Controls for San Antonio Area

| | 1971*<br>tons/yr | 1977<br>tons/yr | 1980<br>tons/yr | 1985<br>tons/yr |
|---|---|---|---|---|
| **Stationary Sources** | | | | |
| Area (trade paints & drycleaning) | 2,004 | 1,142 | 989 | 842 |
| Point Sources | 2,054 | 956 | 1,072 | 1,232 |
| Ship & Barge | -- | -- | -- | -- |
| Gasoline Marketing | | | | |
| Storage Tank Loading | 751 | 988 | 1,099 | 1,301 |
| Vehicle Tank Loading | 1,127 | 1,482 | 1,647 | 1,952 |
| | 5,936 | 4,568 | 4,807 | 5,327 |
| **Mobile Sources** | | | | |
| Gasoline Vehicles | | | | |
| LDV | 22,783 | 19,308 | 16,445 | 14,051 |
| HDV | 1,454 | 1,232 | 1,050 | 897 |
| Diesel Vehicles | 545 | 641 | 710 | 814 |
| Aircraft | 4,483 | 3,299 | 3,473 | 3,816 |
| Other Transportation | 2,178 | 2,172 | 2,167 | 2,249 |
| | 31,443 | 26,652 | 23,845 | 21,827 |
| Grand Totals | 37,379 | 31,220 | 28,652 | 27,154 |

Required Reduction = 45% x Baseline Inventory = 16,821 tons/year

Allowable Emissions = 20,558 tons/year

* Baseline Year

San Antonio Area Counties: Bexar, Comal, and Guadalupe

## Section 5 References

5-1 Texas Air Control Board Report SP-1, "Reactive Carbon Compound Control Strategy Reexamination for the State of Texas," March 13, 1975.

5-2 EPA Office of Air Planning and Standards, Technical Report; *Control of Photochemical Oxidants - Technical Basis and Implementation of Recent Findings*, July 15, 1975.

5-3 EPA Office of Air and Water Programs, Emission Control Tecnology Division. *Aldehyde and Reactive Organic Emissions From Motor Vehicles*, Part I and II. APTD-1568a & b, March 1973.

5-4 Hurr, R. W. *Air Pollution* (A. Stern, Ed), Volume III, 2nd Edition (1968).

5-5 Air Resources Board, State of California, "Light Hydrocarbons in Engine Exhaust and the Los Angeles Atmosphere", Fall 1969.

5-6 EPA Office of Air Quality Planning and Standards, *Report AP42*; Compilation of Air Pollutant Emission Factors; Second Edition, April 1973.

5-7 EPA/U.S. Department of Commerce Report, *Population and Economic Activity in the United States and Standard Metropolitan Statistical Areas*, July 1972.

5-8 Department of the Army Corps of Engineers Annual Report, *Waterborn Commerce of the United States, Part 2, Calendar Year 1972*.

5-9 EPA Office of Air Quality Planning and Standards *Report AP42, Supplement No. 1*, July 1973.

5-10 *American Petroleum Institute Bulletin 2514*, Evaporation Loss from Tank Cars, Tank Trucks, and Maine Vessels, 1957.

5-11 EPA Region VI Letter to 22 Houston Area Industries, from James Doyle, Dated January 29, 1975.

5-12 Exxon Company, USA, *Maine Vapor Recovery Questionnaire*, (2 Volumes) April 17, 1975.

5-13 Exxon Company, USA, Letter to EPA from H. H. Meredith, Jr., dated April 23, 1975.

5-14 Exxon Company, USA, Letter to Texas Air Control Board from J. M. Johnson dated June 9, 1975.

5-15 Texas Air Control Board Report, *Hydrocarbon Control Strategies for the State of Texas*, April 13, 1973.

5-16 *Federal Register*, Volume 38, No. 213, November 6, 1973.

5-17 Garcia, Gaspar, "Automotive Air Pollution," (Mexico Department of Environmental Improvement.) In, *Proceedings Third North American Motor Vehicle Emissions Conference*, September 25-27, 1974.

## 6.0 Control Measures Considered

A number of measures designed to reduce emissions of reactive hydrocarbons have been considered. Several of these affect stationary sources while others affect mobile sources (light-duty vehicles, LDV). The stationary source control measures considered are the extension of Texas Regulation V to additional counties, gasoline marketing vapor recovery, ship and barge vapor recovery, control of emissions from crude petroleum, and control of emissions from degreasing operations. Mobile source controls considered are inspection/ maintenance and reduction in vehicle miles traveled (VMT).

### 6.1 Existing Controls

Existing controls consist of Texas Regulation V for control of volatile carbon compounds from stationary sources in specific Texas counties and motor vehicle emission controls from the Federal Motor Vehicle Control Program. These two categories, in fact, contribute the greatest to hydrocarbon reductions in each area in the Texas plan. The present restudy updated expected emissions from both stationary and mobile sources (see Section 5.0) as a result of: (1) additional sources coming into compliance; (2) addition of sources not included in the original inventory; (3) an update of vehicle population; (4) the effect of the interim Federal motor vehicle emission standards; and (5) an updating of emission factors for in-use vehicles.

### 6.2 Extension of Texas Regulation V

Texas Regulation V, "Control of Air Pollution from Volatile Carbon Compounds," limits hydrocarbon emissions from storage tanks, loading and unloading facilities (except crude oil and ships and barges), water separation units, and waste gas disposal from processing facilities. The regulation presently applies in sixteen counties in Texas which include most of the counties with oxidant problems. Additional reductions can be obtained by extending Texas Regulation V to Hardin County in Beaumont-Port Arthur area and to Tarrant County in the Dallas-Fort Worth area. Requirements of the Texas Regulation V include the following:

1. Storage tanks of greater than 25,000 gallons capacity containing any volatile carbon compounds must be pressure tanks capable of maintaining working pressures and preventing vapor or gas loss to the atmosphere or, otherwise, equipped with a floating roof or vapor recovery device.

2. Loading and unloading facilities for volatile carbon compounds having 20,000 gallons or more throughput per day must be equipped with a vapor recovery system.

3. Water separation units receiving 200 gallons or more of volatile carbon compounds per day must be controlled by tight enclosure, floating roof, or vapor recovery system.

4. Waste gas streams containing specified volatile carbon compounds must be burned in a smokeless flare or direct-flame incinerator at a temperature of at least 1300° F.

The effectiveness of Texas Regulation V in terms of reduction of emission of hydrocarbons where the required controls are applied is about 96-97% for storage tanks, (floating roofs or vapor recovery system), 85% for loading and unloading operations (vapor recovery systems), 98% for water separators (tight enclosures or other devices), and 98% for waste gas streams (incineration). The expected additional reductions in emissions of reactive hydrocarbons by application of Texas Regulation V to Hardin County in the Beaumont-Port Arthur area and to Tarrant County in the Dallas-Fort Worth area shown in the Tables 6-1, 6-2, and 6-3.

## 6.3 Gasoline Marketing Vapor Recovery

Two types of gasoline marketing vapor controls were promulgated on November 6, 1973. These were termed Stage I (filling of storage tanks at service stations and bulk terminals) and Stage II (filling of individual vehicle tanks). In the August 7, 1974 decision, the Court upheld the use of Stage I vapory recovery for some areas, remanded it back to EPA for further consideration for other areas, and invalidated it for still other areas. The original Stage II vapor recovery regulation was remanded back to EPA for further consideration of the need for the regulation in specific areas and technical issues concerning the degree of control required by the regulation.

A typical gasoline distribution pattern consists of delivery by pipeline, barge, or tanker to intermediate storage, then by pipeline or barge to bulk terminals. From the bulk terminal, the gasoline is delivered by tank truck or trailer to the service station or to a bulk plant and then by tank truck to the service station. At the service station, the gasoline is transferred from the tank trucks into storage tanks. Automobiles are refueled from the storage tanks via the service station pump island.

In uncontrolled bulk terminal tank truck loading operations, service station deliveries and automobile refueling, the vapors displaced by the gasoline are normally released directly to the atmosphere. The amount of hydrocarbons which are contained in these vapors is highly variable depending on the manner in which the tank truck is loaded at the terminal; the amount of gasoline contained in the vapors carried by the returning truck; the manner in which the gaoline is delivered to the service station; operator practice in automobile refueling; and a number of other factors such as physical properties of the gasoline; geographical and seasonal effects; and meteorological conditions.

As exhaust emission control standards for motor vehicles become more stringent, the proportional share of hydrocarbon emissions from evaporative losses will increase. Gasoline marketing vapor recovery is designed to reduce hydrocarbon vapor emissions during the filling of tank trucks at bulk terminals, storage tanks at service stations (referred to as Stage I controls) and during the filling of automobile gasoline tanks from these storage tanks at service station pumps (referred to as Stage II controls). The regulation requires that such tanks be equipped with a submerged fill pipe and a system of vapor recovery to prevent release of hydrocarbon vapor to the atmosphere during loading. The vapor recovery system must have an efficiency of at least 90% and can employ a vapor tight vapor return to the tank truck or a refrigeration-condensation system to achieve control. The delivery tank truck must be compatible with the service station system and can only be refilled at facilities with vapor recovery systems. Application of this measure to all seven areas results in reductions shown in Table 6-1 through 6-3.

Two concepts have been developed for Stage II vapor recovery during vehicle fueling; namely, displacement (the balance system) and vacuum assist with secondary recovery. The balance system depends upon the displacement of air and hydrocarbon vapors as a result of pumping gasoline into the automobile fuel tank. Pressure in the tank created by the incoming fuel forces vapor out to the atmosphere under uncontrolled conditions. The balance system is designed to provide an alternative route for those vapors--through a vapor return line to the underground storage tank where it replaces the liquid gasoline which is pumped to the vehicle. Potential points of leakage with the balance system are (1) the vehicle vent, (2) the storage tank vent, (3) the automobile fill neck/fill nozzle interface, and (4) any unforeseen leaks in the system. Automobiles produced since 1970 are equipped with carbon canisters which eliminate losses through the vehicle vents. The bulk of hydrocarbon emissions are released at (1) the automobile fill neck and, to a lesser degree at (2) the storage tank vent (Ref. 6-1).

The vacuum assist system adds two features to the balance concept, i.e., a blower which develops a suction at the nozzle/fill neck interface and a processing unit to recover or otherwise reduce hydrocarbon emissions to the atmosphere. The purpose of the blower is to force displaced vapors to enter the vapor return line rather than leak to the atmosphere. The processing unit condenses,

1977

Table 6-1. Reactive Hydrocarbon Emission Reduction with Possible Control Measures

| | Austin tons/yr (%) | | Beaumont - Port Arthur tons/yr (%) | | Corpus Christi tons/yr (%) | | Dallas - Ft. Worth tons/yr (%) | | El Paso tons/yr (%) | | Houston - Galveston tons/yr (%) | | San Antonio tons/yr (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Stationary Sources** | | | | | | | | | | | | | | |
| Extension of Reg. V | -- | -- | 332 | (0.2) | -- | -- | 2,052 | (1.9) | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | | | | | | | | | |
| Stage I | 357 | (2.1) | 297 | (0.2) | 267 | (0.3) | 2,828 | (2.7) | 272 | (0.8) | 2,551 | (0.8) | 919 | (2.5) |
| Stage II | 483 | (2.9) | 402 | (0.2) | 362 | (0.5) | 3,331 | (3.2) | 368 | (2.3) | 3,003 | (1.0) | 1,082 | (2.9) |
| Crude Oil Storage Control | -- | -- | 5,235 | (3.0) | 1,555 | (2.0) | 331 | (0.3) | -- | -- | 12,292 | (4.0) | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | 1,070 | (0.6) | 365 | (0.5) | -- | -- | -- | -- | 1,724 | (0.6) | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- | 1,217 | (1.2) | -- | -- | 1,217 | (0.4) | 932 | (2.3) |
| **Mobile Sources** | | | | | | | | | | | | | | |
| LDV Inspection/ Maintenance | 420 | (2.5) | 356 | (0.2) | 327 | (0.4) | 2,659 | (2.5) | 359 | (1.1) | 2,636 | (0.9) | 920 | (2.4) |
| VMT Reductions (7%) | 616 | (3.7) | 522 | (0.3) | 480 | (0.5) | 3,906 | (3.7) | 527 | (1.6) | 3,872 | (1.3) | 1,352 | (3.6) |

1980

Table 6-2. Reactive Hydrocarbon Emission Reduction with Possible Control Measures

| | Austin tons/yr (%) | Beaumont - Port Arthur tons/yr (%) | Corpus Christi tons/yr (%) | Dallas - Ft. Worth tons/yr (%) | El Paso tons/yr (%) | Houston - Galveston tons/yr (%) | San Antonio tons/yr (%) |
|---|---|---|---|---|---|---|---|
| Stationary Sources | | | | | | | |
| Extension of Reg. V | -- -- | 332 (0.2) | -- -- | 2,052 (1.9) | -- -- | -- -- | -- -- |
| Gasoline Marketing | | | | | | | |
| Stage I | 394 (2.4) | 370 (0.2) | 296 (0.4) | 3,134 (3.0) | 302 (0.9) | 2,810 (0.9) | 1,022 (2.7) |
| Stage II | 532 (3.2) | 499 (0.3) | 399 (0.5) | 3,692 (3.5) | 408 (2.5) | 3,309 (1.1) | 1,202 (3.2) |
| Crude Oil Storage Control | -- -- | 3,235 (3.0) | 1,555 (2.0) | 331 (0.3) | -- -- | 12,292 (4.0) | -- -- |
| Ship & Barge Vapor Recovery | -- -- | 1,178 (0.7) | 401 (0.5) | -- -- | -- -- | 1,895 (0.6) | -- -- |
| Solvent Control (degreasing) | -- -- | -- -- | -- -- | 1,497 (1.4) | -- -- | 1,497 (0.5) | 1,127 (3.0) |
| Mobile Sources | | | | | | | |
| LDV Inspection/ Maintenance | 308 (1.9) | 289 (0.2) | 238 (0.3) | 1,990 (1.9) | 267 (0.8) | 1,918 (0.6) | 700 (1.9) |
| VMT Reductions (7%) | 507 (3.0) | 476 (0.3) | 391 (0.5) | 3,273 (3.1) | 439 (1.3) | 3,155 (1.1) | 1,151 (3.1) |

1985

Table 6-3. Reactive Hydrocarbon Emission Reduction with Possible Control Measures

| | Austin tons/yr (%) | Beaumont - Port Arthur tons/yr (%) | Corpus Christi tons/yr (%) | Dallas - Ft. Worth tons/yr (%) | El Paso tons/yr (%) | Houston - Galveston tons/yr (%) | San Antonio tons/yr (%) |
|---|---|---|---|---|---|---|---|
| Stationary Sources | | | | | | | |
| Extension of Reg. V | -- -- | 332 (0.2) | -- -- | 2,052 (1.9) | -- -- | -- -- | -- -- |
| Gasoline Marketing | | | | | | | |
| Stage I | 461 (2.8) | 432 (0.2) | 346 (0.4) | 3,725 (3.6) | 359 (1.1) | 3,286 (1.1) | 1,210 (3.2) |
| Stage II | 623 (3.7) | 584 (0.3) | 468 (0.6) | 4,384 (4.2) | 485 (3.0) | 3,866 (1.3) | 1,425 (3.8) |
| Crude Oil Storage Control | -- -- | 5,235 (3.0) | 1,555 (2.0) | 331 (0.3) | -- -- | 12,292 (4.0) | -- -- |
| Ship & Barge Vapor Recovery | -- -- | 1,340 (0.8) | 458 (0.6) | -- -- | -- -- | 2,158 (0.7) | -- -- |
| Solvent Control (degreasing) | -- -- | -- -- | -- -- | 2,036 (1.9) | -- -- | 2,081 (0.7) | 1,510 (4.0) |
| Mobile Sources | | | | | | | |
| LDV Inspections/ Maintenance | 233 (1.4) | 217 (0.1) | 176 (0.2) | 1,556 (1.5) | 199 (0.6) | 1,397 (0.5) | 538 (1.4) |
| VMT Reductions (7%) | 426 (2.6) | 397 (0.2) | 322 (0.4) | 2,845 (2.7) | 363 (1.1) | 2,553 (0.8) | 984 (2.6) |

absorbs, or incinerates hydrocarbon vapors which are not retained in the storage tank. With vacuum assist systems, there is always an influx of additional air caused by the "vacuum sweeper" characteristic of the system. Vacuum assist systems are composed of appreciably more mechanical and other working components than balance systems. However, they are more effective than balance systems since they have the potential of preventing leakage at the nozzle/fill neck interface and of recovering excess hydrocarbons created by "vapor growth" in the vehicle tank. For a more detailed discussion see reference 6-2.

Stage II, for control of hydrocarbon vapors during filling of vehicle tanks, specified that service stations may make such transfer of gasoline only when the dispensing facility is equipped with a system which meets a specific emission limit. This limit depends on the amount of gasoline dispensed by a facility (service station) during a representative calendar year. For a service station which dispenses 360,000 gallons or more of gasoline per year, the emission limit is 0.40 gram of total hydrocarbon vapor per gallon of gasoline dispensed, requiring a vacuum assist vapor recovery system; for a station which dispenses 120,000 gallons or more but less than 360,000 gallons per year, the emissions limit is 0.80 gram of total hydrocarbon vapor per gallon of gasoline dispensed and can usually be obtained with a balance system. Service stations dispensing less than 120,000 gallons of gasoline per year would not be subject to this measure.

Expected reductions in emissions of reactive hydrocarbons for Stage I and Stage II controls for all of the areas for which these measures were considered are shown in the Tables 6-1 through 6-3. Stage I was assumed to provide about 93% reduction and Stage II was assumed to provide about 73% reduction.

## 6.4 Control of Emissions from Crude Petroleum

Evaporative emissions of hydrocarbons from storage tanks occur in all phases of the petroleum industry, from production of crude oil through final storage of finished products in the distribution and marketing system. Hydrocarbon emissions from storage tanks depend essentially on three basic mechanisms: breathing loss, working loss, and standing storage loss. Breathing and working losses are associated with cone or fixed roof tanks, variable vapor space tanks, and low pressure tanks. Standing storage losses are generally associated with floating roof tanks. The magnitude of emissions depends on factors such as the physical properties of the material being stored, climatic conditions, and the size, type, control and condition of the storage tank.

Texas Regulation V is effective in control of hydrocarbon emissions from storage tanks and other facilities and processes to which it applies. However, the regulation contains an exemption for storage tanks containing crude petroleum. Emission inventories show that crude-petroleum storage vessels are a significant source of reactive hydrocarbon emissions in certain areas (see Tables 6-1 through 6-3). This measure requires control of emissions from storage vessels with crude petroleum, having a capacity greater than 100,000 gallons. Such storage vessels, except those located at a drilling and production facility, would be required to be equipped with a floating roof or a vapor recovery system with an efficiency of at least 85%. Expected reductions in reactive hydrocarbon emissions due to application of these controls on crude-petroleum storage in the areas with significant amounts of crude storage are shown in Tables 6-1 through 6-3.

### 6.5 Ship and Barge Vapor Recovery

On November 6, 1973 (38 FR 30626), the EPA promulgated a regulation for control of reactive hydrocarbon emissions from ship and barge loading and unloading facilities in the Houston-Galveston area. This regulation eliminated an exemption for ships and barges in Rule 503 of Texas Regulation V. This meant that ships and barges were subject to the same control as stationary facilities with reference to control of hydrocarbon emissions. Regulation V requires hydrocarbon vapors to be controlled to 1.5 psia Reid vapor pressure. This is equivalent to concentrations in the controlled stream of about 10 percent by volume. In lieu of Texas Rule 503, measures have been designed specifically for application to ship and barge gasoline loading operations in Texas. During unloading operations from a ship or barge to an on shore storage tank, pipeline, or other unit, controls are required by Texas Regulation V (results in over 90 percent recovery). The loading measure regulation requires that, whenever a ship or barge is loaded with gasoline, the emissions of total hydrocarbon vapor must never exceed 5% by volume. In general, this requires that the compartment being filled must be connected to a vapor recovery system. The vapor recovery system is required to have the capability of reducing the total hydrocarbon emissions to the emission limit. Some of the reduction methods that could be applied are refrigeration, incineration, or absorption. This control measure is expected to accomplish a 58% reduction in the ship and barge uncontrolled emissions. This value was based on data submitted by the Exxon Company, Baytown, Texas (Ref. 6-3) for Houston which shows that 90% of the emissions from all ship and barge loading operations in Houston/Galveston are due to gasoline. Refrigeration control equipment is presently available for control to 1.5 percent concentration (at 110 degrees Fahrenheit) and to 5.0 percent concentration (at -70 degrees Fahrenheit). Expected reductions in emissions which would result from this measure are shown in Tables 6-1 through 6-3.

### 6.6 Solvent Control (Degreasing)

Degreasing is a term broadly applied to the use of various organic solvents to dissolve and remove grease and soils from metal objects. If the solvent is near or at room temperature, the process is termed "cold solvent cleaning"; if the solvent is maintained at its boiling point, the process is referred to as "vapor degreasing."

This measure is designed to limit the reactive hydrocarbon emissions from degreasing operations. Emissions from degreasing operations must be controlled by at least 85%. Operations using perchloroethylene and saturated halogenated hydrocarbons are specifically exempt, as are operations emitting less than specified minimal amounts of organic compounds (8 pounds per hour and 40 pounds per day). The regulation for control can be applied in the Dallas-Fort Worth, Houston-Galveston, and San Antonio areas where degreasing operations have been identified as sources of reactive hydrocarbon emissions. Expected reductions for these three areas are shown in tables 6-1 through 6-3.

### 6.7 Inspection-Maintenance of Light-Duty Vehicles

Inspection/maintenance programs aim at reducing emissions from in-use vehicles by ensuring that the emission levels of those vehicles are not permitted to deteriorate due to inadequate or improper maintenance. The programs include two phases: (1) An inspection phase used to screen the vehicle population to determine which vehicles have excessive emissions and require maintenance; (2) a maintenance phase in which appropriate corrective maintenance to achieve low emissions is performed on vehicles with excessive emissions which have failed to pass the inspection test. Recent studies have shown that mandatory inspection-maintenance programs can result in significant reductions in light-duty vehicle emissions (Ref. 6-1). The effectiveness of a program depends primarily upon the type of inspection test and the fraction of the vehicle population induced to receive corrective maintenance.

Two different types of vehicles emission tests have been used: (1) the "idle mode" test, and (2) the "loaded mode test." The idle mode test measures emissions while the engine is running with the transmission in neutral such that there is no load on the engine. The "loaded mode" test measures emissions while the engine is running with the transmission in gear and the drive wheels transmitting power to a treadmill-like device called a dynamometer. A test based on the idle procedure will give an indication of high emissions for vehicles that are poorly maintained or have major mechanical problems. Tests based on the loaded mode procedure determine emissions during simulated driving conditions and in general can single out vehicles having more sophisticated emission related problems, since some poorly performing or malfunctioning engines may show problems only under load. On a technical basis the "loaded test" is more accurate and will single out more high emission vehicles. However, it is considerably more costly to operate, requires a large initial capital investment, and needs a more expert operator to perform the tests. In addition, the loaded mode test is more suited to a high volume centrally located (such as a state inspection station) operation. The idle mode can be either centrally located or under the operation of individually licensed garage owners. Since Texas presently has a vehicle safety inspection program operated by licensed privately-owned garages, it appears more practical to use the idle mode test operated as part of the privately licensed safety inspection program. Therefore, the inspection/maintenance program has been set up for an idle mode test.

The two main provisions of the inspection/maintenance program are the requiement for emission tests using the idle mode and the requirement for the State to set emission tests pass-fail criteria such that an overall 8 percent reduction in light duty vehicle exhaust hydrocarbon emissions is obtained in the first test cycle.

The provision for an average of 8 percent reduction in light-duty vehicle exhaust emissions during the first inspection cycle requires the State to design emission test pass-fail criteria. Any type of program which meets the 8 percent reduction will satisfy this requirement. Typically, programs designed by other states have allowed higher emission levels for older uncontrolled or less-controlled vehicles and lower levels for well-controlled newer models. For example, in New Jersey, vehicles are grouped into four model year categories; pre-1968, 1968 to 1969, 1970 to 1974, and 1975. Hydrocarbon emission limits by category range from 1,600 to 200 parts per million, the philosophy being that a well-tuned older vehicle (uncontrolled or partly controlled) could not meet stringent limits for a well-tuned newer, controlled vehicle.

The estimated reductions in emissions of reactive hydrocarbons are shown for each area in the accompanying Tables 6-1 through 6-3.

## 6.8 VMT Reduction Measures

Average automobile occupancy in the U.S. is about two persons per car. Average occupancy for work trips is about 1.4 persons per car. Since most cars are capable of carrying at least four persons, there is considerable room for reducing automobile use and emissions through carpooling. In order for carpooling to be successful, carpoolers must have trip origins and destinations that are close to one another, must desire to travel at the same times of day, and, to minimize the problems of locating carpool partners, must make trips that are repetitive from day to day. As a result, the greatest potential for increased carpool use is in connection with peak-period work trips. These trips are responsible for about 25 percent of urban area automobile emissions. The present low occupancy factor for work trips indicates that such travel is especially conducive to carpooling, and a prime potential area for VMT reduction if adequate incentives to encourage carpooling are presented. Preliminary indications are that programs to encourage carpooling should be capable of reducing total urban area automobile emissions by 5 to 10 percent (Ref. 6-4).

The speed and reliability of bus service can be increased substantially by allocating road facilities preferentially to buses through the use of reserved lanes on existing highways, specially constructed busways, or other means. Certain forms of priority treatment can be applied to carpools so as to increase their speed and, thereby, their attractiveness. Within the last decade, over 200 bus priority treatments have been implemented or proposed in the United States and elsewhere (Ref. 6-5).

Examples of bus priority treatment on freeways include:

The San Bernardino Busway in the Los Angeles area and the Shirley Busway in the Washington, D.C. area;

Contra-flow bus lanes on the Long Island Expressway (New York City), I-495 in New Jersey, the Southeast Expressway in Boston, and U.S. 101 in Marin County, California;

A special bus ramp for Seattle's Blue Streak express bus service, and the bus-carpool bypass lanes at the San Francisco-Oakland Bay Bridge toll plaza.

Examples of priority treatment on surface streets include:

Dedicated bus streets in Chicago and Minneapolis;

Contra-flow bus lanes in San Juan, Louisville, and San Antonio;

Median bus lanes in Chicago and New Orleans, and curb bus lanes in most major cities.

Priority treatment can increase bus freeway speeds by a factor of two or more without significantly affecting auto speeds (Refs. 6-5, 6-6). Speed increases of up to 50 percent have resulted from surface street priority treatment (Ref. 6-7).

The prospective measures for Texas consist of three regulations (VMT reduction measures) aimed at reducing average daily VMT in certain problem areas where the oxidant problem is especially acute and where automobile transportation accounts for an appreciably high percent of total reactive hydrocarbon emissions. These regulations deal with employer incentive programs to encourage use of mass transit and carpooling, preferential bus/carpool treatment, and commuter/carpool matching. These measures for VMT reduction are designed to supplement and reinforce one another. Their effectiveness derives from the three measures acting concurrently. When fully implemented and applied as an entire group, it is intended and anticipated that these measures would result in areawide VMT reductions of about 7%, with a corresponding reduction in emissions of hydrocarbons from light-duty vehicles. The expected reductions in emissions of reactive hydrocarbons for 1977, 1980, and 1985 due to application of this group of measures in each of the areas where considered are shown in Tables 6-1, 6-2, and 6-3.

### 6.8.1. Employer Incentive Programs

These programs are designed by employers to provide incentives to the use of mass transit and carpools by employees in their regular commuting to and from work. Under this approach, an employer has the flexibility to develop his own program to reduce average daily VMT applicable to a facility. The concept is based on known existing programs which have been developed by employers to encourage multiple-passenger automobile use in regular work-related commuting, and thereby to conserve fuel. The employer incentive regulation in the present action calls for a program to reduce average daily VMT applicable to an affected facility by 15%, or alternatively, to attain a commuter/vehicle occupancy ratio, applicable to all commuters to the facility by private motor vehicle, of 1.75 or greater. The measure applies to employment facilities with 250 or more employees and to educational facilities of college level or of vocational training above the secondary level with 1,000 or more employees and students. Based on employment data by size of facility in five counties (Dallas, Tarrant, Harris, Galveston, and Bexer) in which the employer incentive measure would apply, the 250-employee figure for employment facilities would result in the following percentages of employees being included within employer incentive programs: 57% of employees in manufacturing industries, 33% of employees in commercial activities (insurance, banking, retail), and 44% of employees in transportation industries. For all three types of employment (manufacturing, commercial, and transportation), the average figure of employee coverage is 44% - of more than one million employees included in the data on which these figures are based (Refs. 6-8 and 6-9). With reference to educational facilities (colleges and universities), approximately

95% of employees and students are located at facilities with population of 1,000 or more (employees and students) and would thus be included within employer incentive programs (in the same five counties)(Ref. 6-10). Tables 6-4, 6-5, and 6-6 show employment data by size of facility for manufacturing, commercial, and transportation industries. Table 6-7 provides population data for educational facilities.

In the event an employer or educational institution does not achieve either of the above goals (reduction in average daily VMT of 15% or attainment of a commuter/vehicle occupancy ratio of 1.75 or greater) for a facility by the applicable compliance date, certain measures must be adopted to encourage use of mass transit and carpools. These are as follows:

(1) Providing a commuter/carpool matching program.

(2) Establishing park and ride facilities.

(3) Subsidizing the costs of carpool and transit trips by commuters.

(4) Establishing shuttle bus service and vanpool programs.

(5) Publicizing schedules, rates, and routes of all forms of mass transit which serve the facility.

(6) Cooperating and negotiating with authorities in charge of mass transit for improved service to the facility.

The compliance date for a facility depends on whether it is an employment or an educational facility, and its size. Compliance dates extend from October 1, 1976, to December 1, 1976. The regulation includes a requirement for reporting to the Regional

## TABLE 6-4. EMPLOYMENT DATA BY SIZE OF FACILITY
Manufacturing
Reference: Directory of Texas Manufactures - 1973

| No. Employees | Under 8 | 8-24 | 25-49 | 50-99 | 100-249 | 250-499 | 500-999 | 1,000-4,999 | 5,000 and Over | Total No. Employees | No. Employees At Facilities of 250 Employees and Larger |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bexar County** | | | | | | | | | | | |
| No. Employment Locations | 161 | 162 | 76 | 48 | 56 | 16 | 10 | -- | -- | -- | -- |
| Estimated No. Employees | 805 | 2,592 | 2,812 | 3,600 | 9,800 | 6,000 | 7,500 | -- | -- | 33,109 | 13,500 |
| Percent of Total No. Employees | 2% | 8% | 8% | 11% | 30% | 18% | 23% | -- | -- | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 98% | 90% | 82% | 71% | 41% | 23% | -- | -- | -- | -- |
| **Dallas County** | | | | | | | | | | | |
| No. Employment Locations | 448 | 542 | 282 | 220 | 181 | 54 | 22 | 9 | 2 | -- | -- |
| Estimated No. Employees | 2,240 | 8,672 | 10,434 | 16,500 | 31,675 | 20,250 | 16,500 | 27,000 | 25,000 | 158,271 | 88,750 |
| Percent of Total No. Employees | 1% | 6% | 7% | 10% | 20% | 13% | 10% | 17% | 16% | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 99% | 93% | 86% | 76% | 56% | 43% | 33% | 16% | -- | -- |

Table 6-4 Contd.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Galveston County** | | | | | | | | | | | |
| No. Employment Locations | 35 | 22 | 11 | 12 | 3 | 8 | 0 | 4 | -- | -- | -- |
| Estimated No. Employees | 175 | 352 | 407 | 900 | 525 | 3,000 | 0 | 12,000 | -- | 17,359 | 15,000 |
| Percent of Total No. Employees | 1% | 6% | 7% | 10% | 20% | 17% | 0% | 69% | -- | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 98% | 96% | 94% | 89% | 86% | 69% | 69% | -- | -- | -- |
| **Harris County** | | | | | | | | | | | |
| No. Employment Locations | 556 | 667 | 339 | 206 | 179 | 69 | 29 | 14 | -- | -- | -- |
| Estimated No. Employees | 2,780 | 10,672 | 12,543 | 15,543 | 31,325 | 25,625 | 21,750 | 42,000 | -- | 162,395 | 89,625 |
| Percent of Total No. Employees | 2% | 6% | 8% | 10% | 19% | 16% | 13% | 26% | -- | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 98% | 92% | 84% | 74% | 55% | 39% | 26% | -- | -- | -- |
| **Tarrant County** | | | | | | | | | | | |
| No. Employment Locations | 303 | 280 | 168 | 130 | 93 | 28 | 8 | 5 | 2 | -- | -- |
| Estimated No. Employees | 1,515 | 4,480 | 6,216 | 9,750 | 16,275 | 10,500 | 6,000 | 15,000 | 25,000 | 94,736 | 56,500 |
| Percent of Total No. Employees | 2% | 5% | 7% | 10% | 17% | 11% | 6% | 16% | 26% | --- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 98% | 93% | 86% | 76% | 59% | 48% | 42% | 26% | -- | -- |

TOTALS (5 Counties) - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 465,870 263,375

Percen of Total No. Employees at Facilities of 250 Employees and Larger - - - - - - - - - - - - - - - - - - - - - - - - - - - - - 57%

## TABLE 6-5. EMPLOYMENT DATA BY SIZE OF FACILITY
### Commercial
### (Insurance, Banking, Retail)

Reference: 1973 County Business Patterns, Texas

| | Under 100 | 100 - 249 | 250 - 499 | 500 and over | Total No. Employees | No. Employees at Facilities of 250 Employees and Larger |
|---|---|---|---|---|---|---|
| **Bexar County** | | | | | | |
| No. Employment Locations | 4,753 | 95 | 18 | 14 | -- | -- |
| Estimated No. Employees | 40,688 | 16,625 | 6,750 | 14,000 | 78,063 | 20,750 |
| Percent of Total No. Employees | 52% | 21% | 9% | 18% | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 47% | 27% | 18% | -- | -- |
| **Dallas County** | | | | | | |
| No. Employment Locations | 9,051 | 157 | 61 | 45 | -- | -- |
| Estimated No. Employees | 88,473 | 27,475 | 22,475 | 45,000 | 183,823 | 67,875 |
| Percent of Total No. Employees | 49% | 15% | 12% | 24% | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 51% | 36% | 24% | -- | -- |
| **Galveston County** | | | | | | |
| No. Employment Locations | 1,131 | 12 | 1 | 1 | -- | -- |
| Estimated No. Employees | 8,362 | 2,100 | 375 | 1,000 | 11,837 | 1,375 |
| Percent of Total No. Employees | 70% | 18% | 3% | 9% | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 30% | 12% | 9% | -- | -- |

Table 6-5 Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| **Harris County** | | | | | | |
| No. Employment Locations | 10,567 | 199 | 41 | 47 | -- | -- |
| Estimated No. Employees | 89,699 | 34,825 | 15,375 | 47,000 | 186,899 | 62,375 |
| Percent of Total No. Employees | 48% | 19% | 8% | 25% | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 52% | 33% | 25% | -- | -- |
| **Tarrant County** | | | | | | |
| No. Employment Locations | 1,141 | 16 | 3 | 2 | -- | -- |
| Estimated No. Employees | 8,827 | 2,800 | 1,125 | 1,000 | 14,752 | 3,125 |
| Percent of Total No. Employees | 59% | 19% | 8% | 14% | -- | -- |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 41% | 22% | 14% | -- | -- |
| TOTALS (5 Counties) | | | | | 475,374 | 155,500 |
| Percent of Total No. Employees At Facilities of 250 Employees and Larger | | | | | | 33% |

## TABLE 6-6. EMPLOYMENT DATA BY SIZE OF FACILITY
### Transportation

Reference: 1973 County Business Patterns, Texas

| | Under 100 | 100 - 249 | 250 - 499 | 500 and over | Total No. Employees | No. Employees at Facilities of 250 Employees and Larger |
|---|---|---|---|---|---|---|
| Bexar County | | | | | | |
| No. Employment Locations | 288 | 14 | 1 | 2 | -- | -- |
| Estimated No. Employees | 5,974 | 2,450 | 375 | 2,000 | 10,799 | 2,375 |
| Percent of Total No. Employees | 55% | 23% | 3% | 19% | | |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 45% | 22% | 19% | | |
| Dallas County | | | | | | |
| No. Employment Locations | 308 | 34 | 15 | 21 | | |
| Estimated No. Employees | 18,763 | 5,950 | 5,625 | 21,000 | 51,338 | 26,625 |
| Percent of Total No. Employees | 35% | 12% | 11% | 41% | | |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 64% | 52% | 41% | | |
| Galveston County | | | | | | |
| No. Employment Locations | 118 | 5 | 5 | -- | | |
| Estimated No. Employees | 2,165 | 875 | 1,875 | -- | 4,915 | 1,875 |
| Percent of Total No. Employees | 44% | 18% | 38% | -- | | |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 56% | 38% | -- | | |

Table 6-6 Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| Harris County | | | | | | |
| No. Employment Locations | 1,033 | 58 | 20 | 19 | | |
| Estimated No. Employees | 23,688 | 10,150 | 7,500 | 19,000 | 60,338 | 26,500 |
| Percent of Total No. Employees | 39% | 17% | 12% | 32% | | |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 61% | 44% | 32% | | |
| Tarrant County | | | | | | |
| No. Employment Locations | 275 | 10 | 1 | 4 | | |
| Estimated No. Employees | 5,549 | 1,750 | 375 | 4,000 | 11,674 | 4.375 |
| Percent of Total No. Employees | 48% | 15% | 3% | 34% | | |
| Cumulative Percent of Employees at Facilities of Stated Size and Larger | 100% | 52% | 37% | 34% | | |
| TOTALS (5 Counties) | | | | | 139,064 | 61,750 |
| Percent of Total No. Employees at Facilities of 250 Employees and Larger | | | | | 44% | |

## TABLE 6-7. STUDENT AND FACULTY POPULATION AT EDUCATIONAL FACILITIES

Reference: Texas Almanac, 1974-1975

| | Total Student and Faculty Population | Student and Faculty Population at Educational Facilities with 1,000 or More Students and Faculty |
|---|---|---|
| **Bexar County** | | |
| (7 Colleges and Universities) | 32,844 | 32,146 |
| **Dallas County** | | |
| (10 Colleges and Universities) | 40,087 | 37,178 |
| **Galveston County** | | |
| (2 Colleges and Universities) | 2,622 | 1,651 |
| **Harris County** | | |
| (13 Colleges and Universities) | 56,636 | 53,489 |
| **Tarrant County** | | |
| (7 Colleges and Universities) | 39,406 | 38,876 |
| TOTALS (5 Counties) | 171,595 | 163,340 |

Percent of Total Student and Faculty Population at Facilities of 1,000 or More Students and Faculty - - - - - - - - - - - - - - 95%

Administrator on the incentive program within one month after the compliance date, and annually thereafter. For a facility which has not achieved either goal stipulated above by the applicable compliance date, the employer or educational institution is required to report to the Regional Administrator with a complete description of all measures which it has applied in the incentive program, indicating the consideration given to measures which it has not applied, and providing an explanation of the probable reasons why neither of the goals has been accomplished.

### 6.8.2. Preferential Bus/Carpool Treatment

This consists of measures such as exclusive bus/carpool lanes designed to speed and facilitate the flow of bus and carpool traffic, and thereby make such forms of transportation more attractive to commuters. The present action requires selected cities to develop and implement a plan to provide preferential bus/carpool treatment and to reduce average daily VMT by 8% from that existing during the base period of July 1 - September 30, 1974. Such measures may consist of any one or combination of the following:

(1) Exclusive bus/carpool lanes or other preferential bus/carpool treatment on main thoroughfares.
(2) Park and ride facilities.
(3) Dial-a-bus system.
(4) Restricted use of ramps leading to and from thoroughfares.
(5) Restriction of on-street parking in congested areas.
(6) Vehicle-free or bus-only zones.
(7) Other measures designed to reduce average daily VMT.

Each measure may be restricted to certain hours and/or days of heaviest traffic flow. For the purpose of determining compliance with the required reduction in average daily VMT, comparison of the predicted average daily VMT for the period of March 1 - May 31, 1977, is to be made with average daily VMT for the base period. The plan is to be fully implemented by May 31, 1977.

A report describing the plan and the measures to which consideration was given, indicating those measures to be instituted, and containing estimates of the VMT reductions expected, is to be submitted to the Regional Administrator by May 31, 1976. The report is to contain compliance schedules, with the compliance date for each measure to be not later than May 31, 1977. Following receipt of the report, the Regional Administrator shall make a determination of the approvability of the plan by July 31, 1976, and may require additional measures if he determines that the city is not utilizing all feasible measures to meet the required reduction in average daily VMT. He may also require revisions in a compliance schedule if he determines that implementation of a measure will not be made as expeditiously as practicable.

Each affected city is to strive for cooperation and joint effort by other cities and governmental entities adjacent to its boundaries, to encourage such cities and entities to take such action as may directly improve the effectiveness of the measures to be implemented. Each affected city also is to publicize its plan of preferential bus/carpool treatment and VMT reduction so as to gain the understanding, cooperation, and support of the public.

The cities to which this regulation applies have already completed elaborate transportation and traffic studies, the results of which may be utilized in considering and adopting measures for preferential bus/carpool treatment. Measures contained in any city plan not yet placed in effect may be part of the plan presented to comply with this regulation. In estimating city-wide VMT reductions, the affected cities should consider the reductions in VMT which are expected due to application of the employer incentive regulation.

### 6.8.3. Commuter/Carpool Matching

The present action contains a measure for the establishment of a commuter/carpool matching system by selected cities, to encourage commuters to facilities in each respective city to form and utilize carpools. The system is to be designed to facilitate initial contact between commuters with similar travel patterns to the same or neighboring facilities. The system is to utilize computer processing equipment for the purpose of matching names, travel origins and destinations, and travel times of commuters to facilities in each affected city. The measure is considered to be one of general support to reduction of average daily VMT in the effected cities and, as such, is designed to serve commuters to facilities in each affected city whether or not they are included in employer incentive programs.

The commuter/carpool matching system for each affected city is to provide for the following functions and services to commuters and facilities in that city:

(1) Preparation and distribution of a manual to each facility describing the commuter/carpool matching system and providing directions and guidance for obtaining information from commuters on travel patterns and for the proper preparation of computer cards to be processed in the commuter/carpool matching system.

(2) Distribution to any commuter, upon request, of directions and forms to be completed which can be used by the city to enter appropriate information into a computer program for the purpose of commuter/carpool matching.

(3) Processing of any set of properly prepared computer cards for 250 or more commuters to an employment facility, and for 1,000 or more commuters to an educational facility, submitted by a facility to show results of commuter/carpool matching in terms of commuters who have similar travel patterns.

(4) Processing of properly prepared information submitted by any commuter to show results of commuter/carpool matching.

(5) Distribution of results of commuter/carpool matching to each facility which submitted a set of properly prepared computer cards.

(6) Distribution of results of commuter/carpool matching to any commuter who submitted properly prepared information.

(7) Technical assistance on request of a facility with respect to initiating and maintaining a carpool program and to improving its effectiveness.

The final compliance date for implementation of the commuter/carpool matching system by each affected city is July 1, 1976, with a final report on the system and the status of compliance due one month thereafter.

## Section 6 References

6-1 Control Stategies for In-use Vehicles, U.S. Environmental Protection Agency, Mobile Source Pollution Control Program, Washington, D.C. 20460, November 1972.

6-2 EPA Report 450/375-046-a, A Study of Vapor Control Methods for Gasoline Marketing Operations; Volume I - Industry Survey and Control Techniques, April 1975.

6-3 Exxon Company, USA, Letter to Texas Air Control Board, from J. M. Johnson, dated June 9, 1975.

6-4 Transportation Controls to Reduct Automobile Use and Improve Air Quality in Cities, U.S. Environmental Protection Agency, Office of Air and Waste Management, Washington, D.C. 20460, November 1974.

6-5 Bus Use of Highways: State of the Art, Report No. 143, National Cooperative Highway Research Program, Highway Research Board, 1973.

6-6 Gerald K. Miller and Keith M. Goodman, The Shirley Highway Express-Bus-on-Freeway Demonstration Project-First Year Results, Interm Report No. 2, prepared for the Urban Mass Transportation Administration, November 1972.

6-7 Downtown Distribution Plan San Bernardino Freeway Express Busway, prepared by Wilbur Smith and Associates for the Southern California Rapid Transit District, March 1973.

6-8 Directory of Texas Manufacturers, 1973, Bureau of Business Research, University of Texas at Austin.

6-9 1973 County Business Patterns, Texas, U.S. Department of Commerce, Bureau of the Census.

6-10 Texas Almanac, 1974-75. Dallas Morning News.

## 7.0 Recommended Control Measures

In the EPA restudy of the hydrocarbon/photochemical oxidant control plan for Texas, the Agency reviewed the specific strategies promulgated on November 6, 1973, and considered some additional measures not used in the original plan. In trying to determine what control measures were needed versus the reasonableness of the measures and their socio-economic impact, a general priority ranking was set up according to the following scheme: Application of existing controls was ranked at the top; extension of existing stationary source controls to areas not covered by the State-submitted plan (April 15, 1973) was considered next; subsequently additional source controls were applied; this was followed by moderate controls on motor vehicles; and finally some methods which could have significant socio-economic impact were examined but not applied. Added to the November 6, 1973 promulgation is a proposal to control hydrocarbon vapor losses from storage of crude oil. Substantial reductions of hydrocarbons can be obtained in some areas by this additional measure. Measures included in the original plan that are not recommended for the present strategy are light-duty vehicle retrofit, limitation of new reactive carbon compound emission sources, gasoline limitations, and parking management.

Although the recommended amendments to the plan would take no specific action on existing controls the effects of existing controls were considered in development of the plan. Existing controls consist of Texas Regulation V for control of volatile carbon compounds from stationary sources in specified Texas counties and control of motor vehicle emissions as required by the Federal Motor Vehicle Control Program. These two categories, contribute the greatest to hydrocarbon reductions in each area in the Texas plan.

It is also worthy of note that all of the measures being proposed are conservative of petrochemical products in addition to reducing emissions of hydrocarbons to the atmosphere. A consideration has been given to the socio-economic impact of both the recommended and other potential hydrocarbon emission reduction measures. None of the measures presently being recommended are considered to have a disruptive socio-economic impact. In selecting the recommended measures, the highest priority was put on stationary source controls with mobile source controls coming next. Measures recommended include control of crude oil vapor losses, control of gasoline marketing vapor losses, control of solvent (degreasing) vapor losses, control of gasoline vapor losses from loading of ships and barges, light-duty vehicle inspection and maintenance, and some measures to reduce vehicle miles traveled.

The recommended measures for each area in Texas are listed in Tables 7-1A and 7-1B. Table 7-1A presents the EPA Long Range Oxidant Plan and includes the minimum reasonable measures that are recommended for ultimate application in each of the seven Texas oxidant problem areas. From the list of minimum reasonable measures given in Table 7-1A, another list of measures has been chosen for

Table 7-1A--Recommended Additional Controls for Texas Long Range Oxidant Plan

| | Austin | Beaumont Pt. Arthur | Corpus Christi | Dallas Ft. Worth | El Paso | Houston Galveston | San Antonio |
|---|---|---|---|---|---|---|---|
| Additional Stationary Source Controls | | | | | | | |
| Extension of Reg. V | - | X | - | X | - | - | - |
| Gas Marketing--Stage I | X | X | X | X | X | X | X |
| Gas Marketing--Stage II | X | X | X | X | X | X | X |
| Ship & Barge Controls | - | X | X | - | - | X | - |
| Solvent Controls (degreasing) | - | - | - | X | - | X | X |
| Crude Oil Storage Control | - | X | X | X | X | X | - |
| Additional Mobile Source Control | | | | | | | |
| Inspection-Maintenance | - | - | - | X | - | X | X |
| VMT Measures | - | - | - | X | - | X | X |

X = Measure Proposed

- = Not Proposed

### Table 7-1B--Recommended Additional Controls for Texas Interim Oxidant Plan

| | Austin | Beaumont Pt. Arthur | Corpus Christi | Dallas Ft. Worth | El Paso | Houston Galveston | San Antonio |
|---|---|---|---|---|---|---|---|
| **Additional Stationary Source Controls** | | | | | | | |
| Extension of Reg. V | - | S | - | S | - | - | - |
| Gas Marketing--Stage I | S | S | S | E | S | E | E |
| Gas Marketing--Stage II | - | - | - | E | - | E | - |
| Ship & Barge Controls | - | - | - | - | - | E | - |
| Solvent Controls (degreasing) | - | - | - | S | - | S | S |
| Crude Oil Storage Control | - | S | S | S | S | S | - |
| **Additional Mobile Source Control** | | | | | | | |
| Inspection-Maintenance | - | - | - | E | - | E | - |
| *VMT Measures | - | - | - | S | - | S | S |

E = Measure Proposed by EPA

S = Measure Proposed by State

- = Not Proposed

* State to obtain commitments from cities

implementation now as an interim plan. These interim measures are presented in Table 7-1B. The implementation responsibilities shown for TACB in Table 7-1B are based on a resolution by the TACB to adopt such measures. In most Texas areas, additional controls beyond those recommended in either Table 7-1A or Table 7-1B will have to be implemented before the control plan can provide for air quality levels even approaching the standard and before the plan can be considered final. This approach will result in a series of promulgated regulations. The interim control measures will comprise the first set of regulations in the series, the remaining long range measures will comprise the second set of regulations, and regulations requiring other control measures will be added as identified.

Figures 7-1 through 7-7 show the expected effects of the existing and long range controls on air quality in each of the areas from the baseline year through 1985. Detailed discussions of the interim and long range measures chosen and their effects in each area are presented in Sections 7.1 through 7.7. The cost effectiveness of the plan is discussed in Section 7.8.

## 7.1 Austin Area Recommended Controls

The additional long range controls recommended for the Austin area consist of requirements for vapor recovery for gasoline transfers to storage tanks (Stage I) and to vehicle tanks (Stage II). The effects of these measures are presented in Table 7-2A. As shown in the table, there will remain further reductions required to meet the standard even in 1985, but substantial progress toward the required 50% reduction will be made.

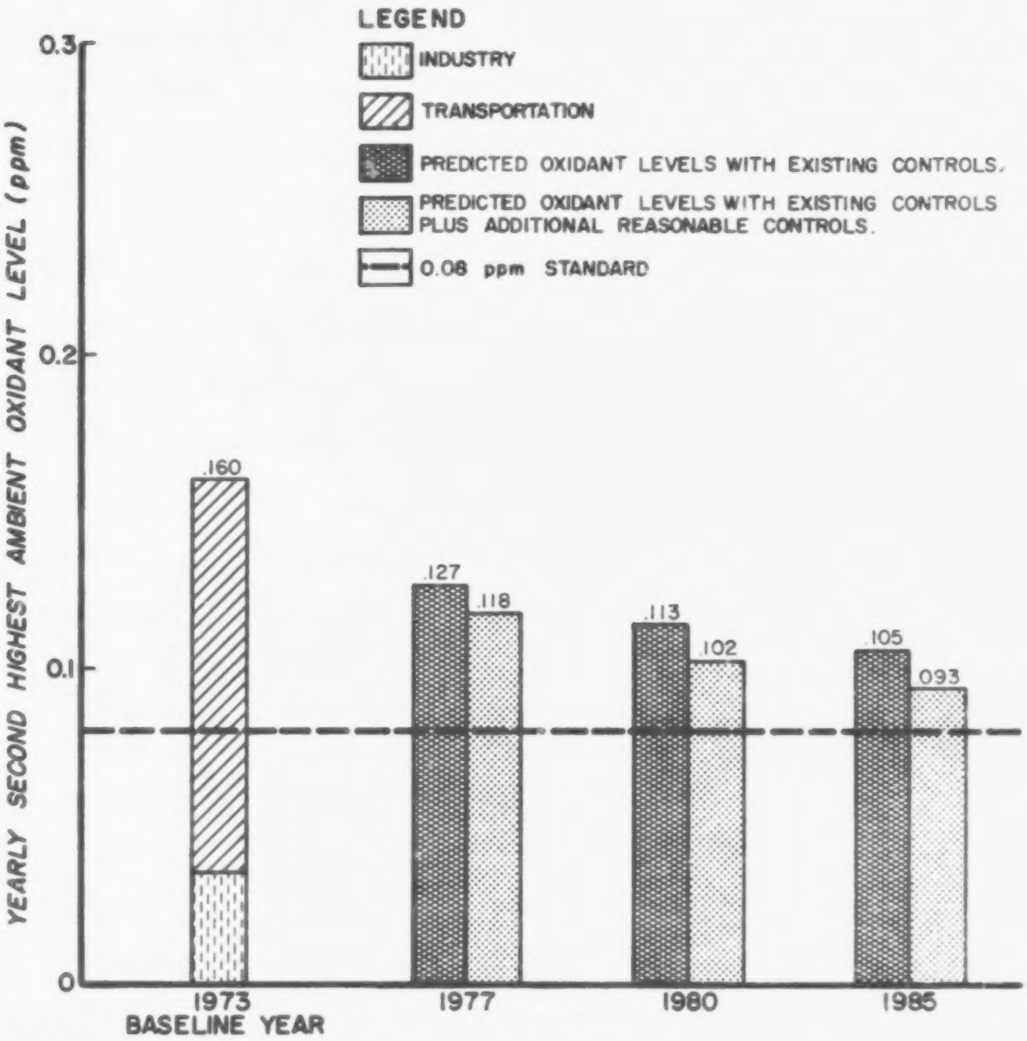

FIG. 7-1 OXIDANT LEVELS 1973-1985 (AUSTIN)

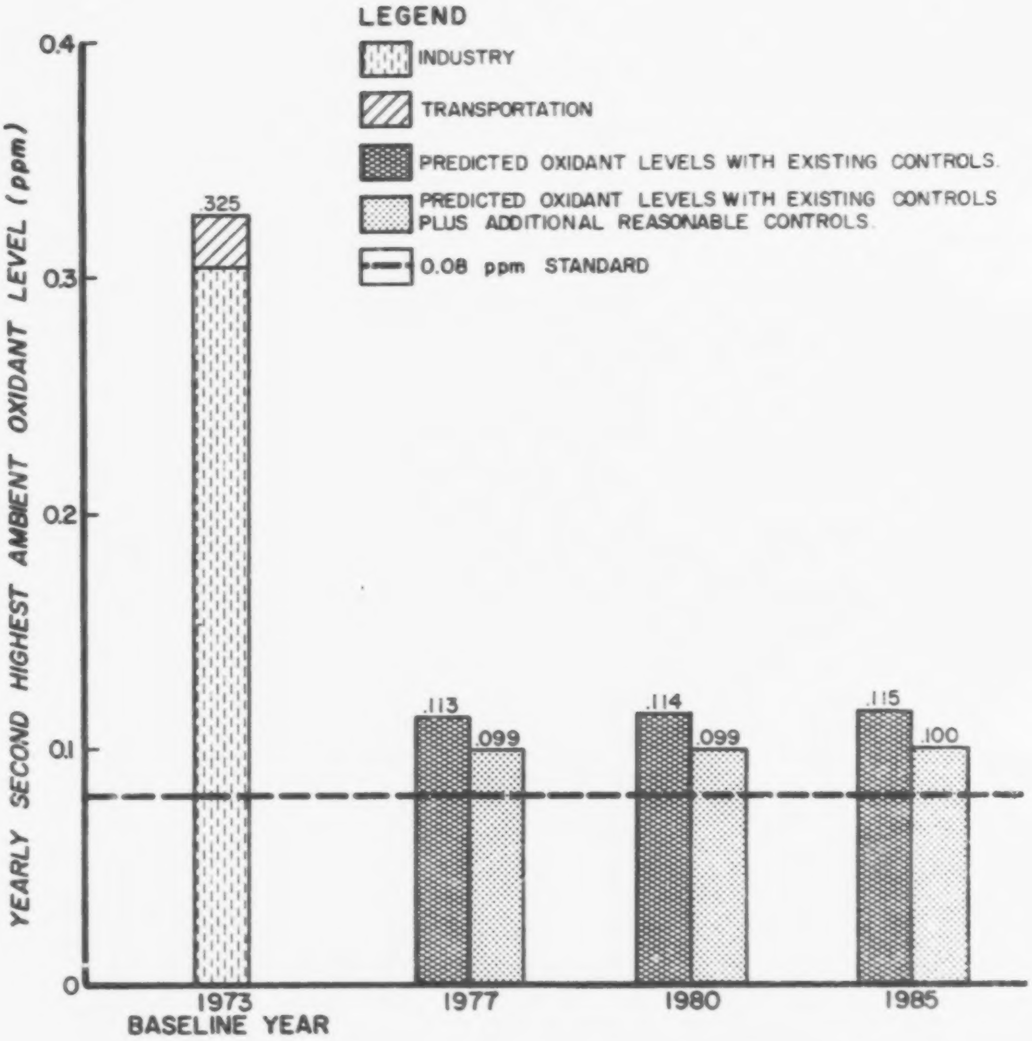

FIG. 7-2 OXIDANT LEVELS 1973-1985 (BEAUMONT/PORT ARTHUR)

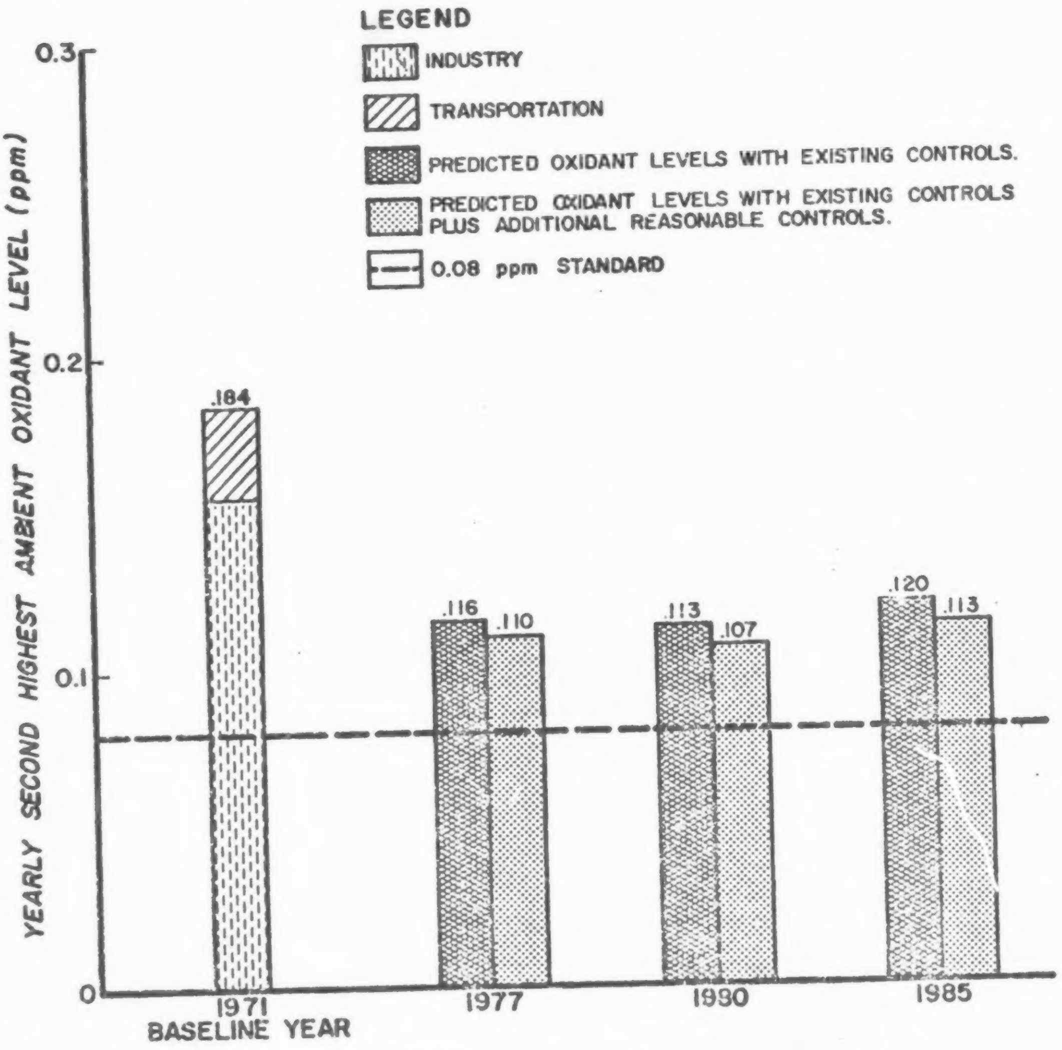

FIG. 7-3 OXIDANT LEVELS 1971–1985 (CORPUS CHRISTI)

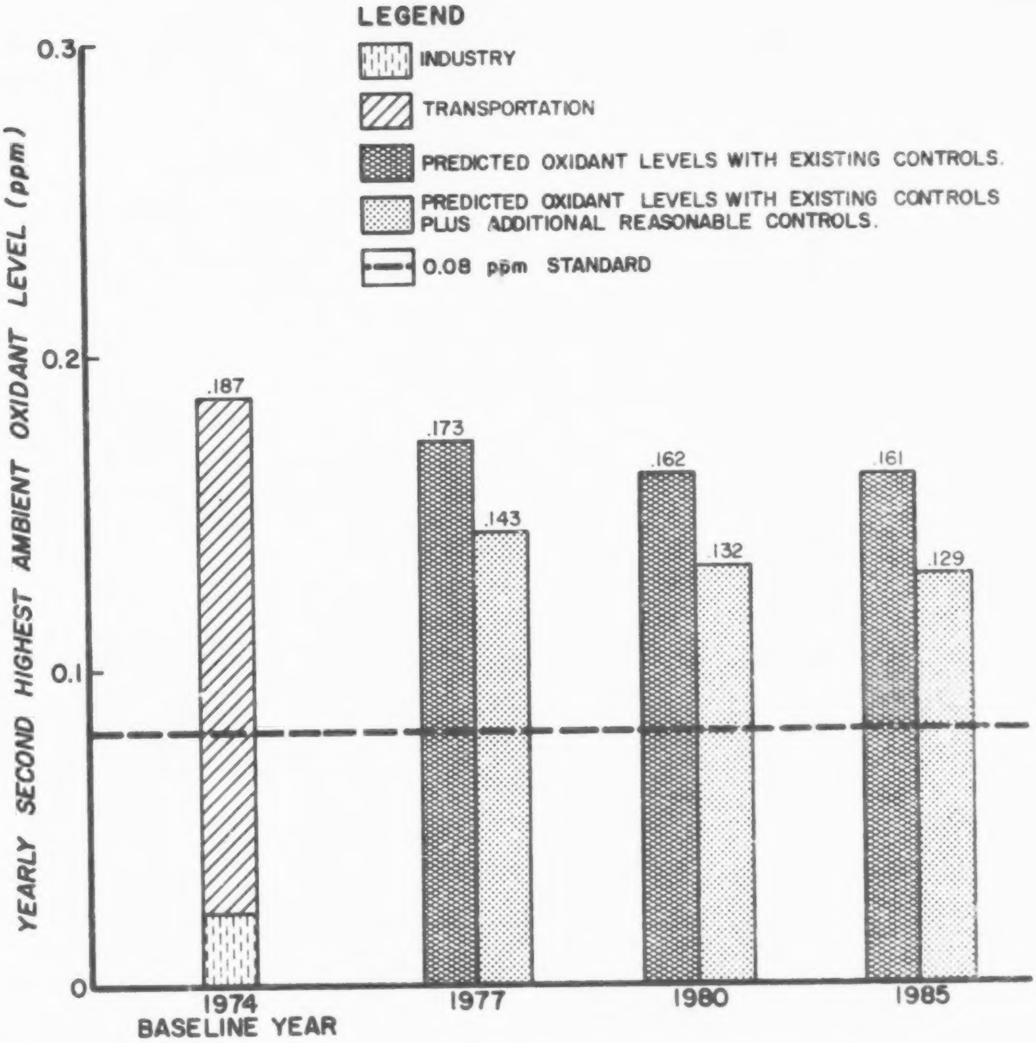

FIG. 7-4 OXIDANT LEVELS 1974–1985 (DALLAS/FORT WORTH)

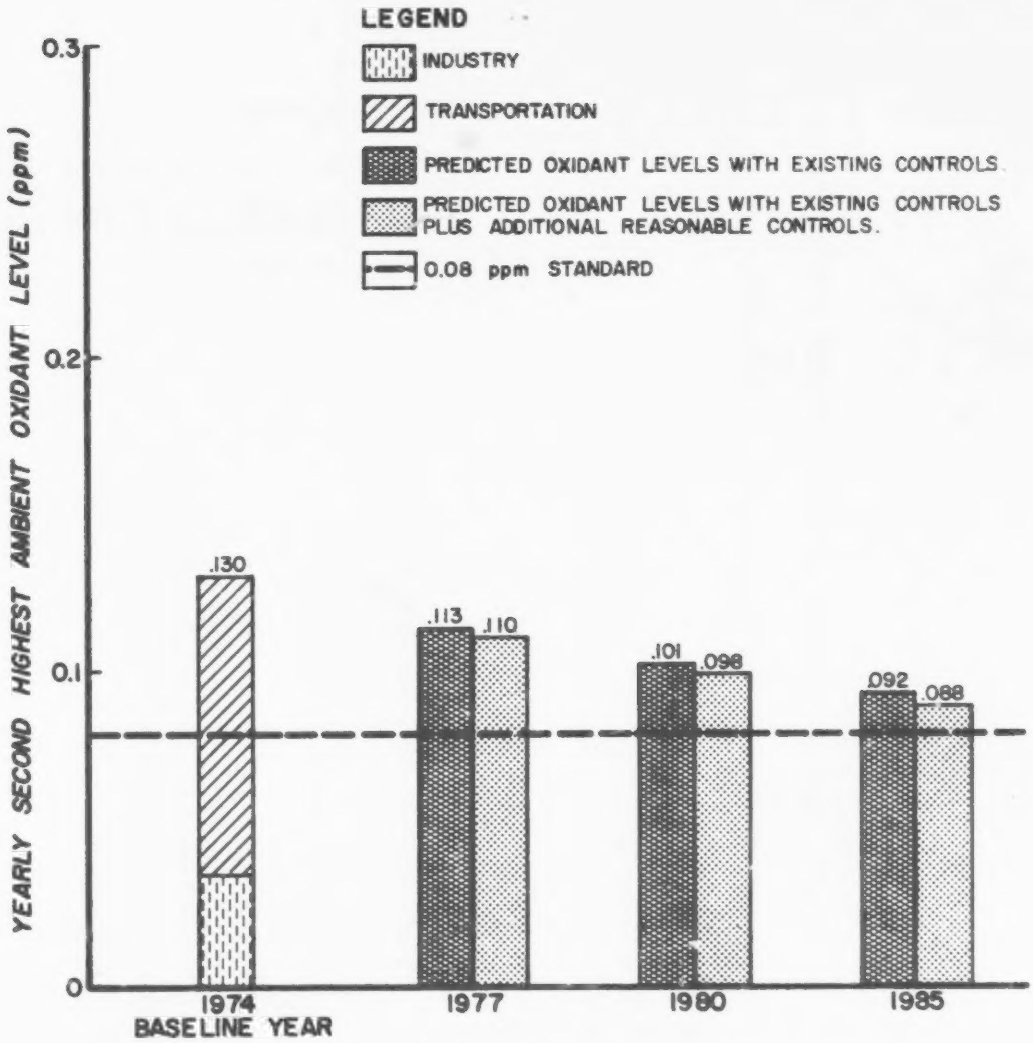

FIG. 7-5 OXIDANT LEVELS 1974 – 1985 (EL PASO)

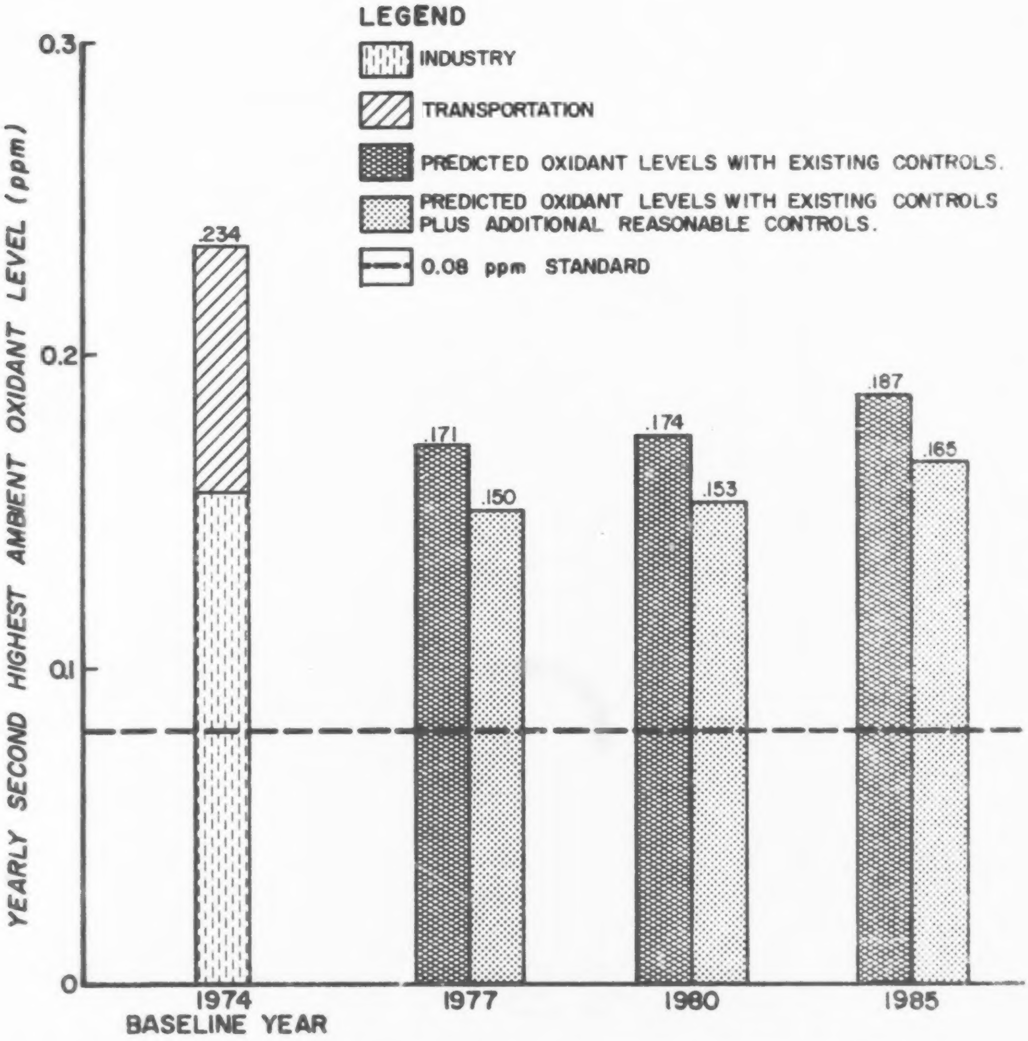

FIG. 7-6 OXIDANT LEVELS 1974-1985 (HOUSTON/GALVESTON)

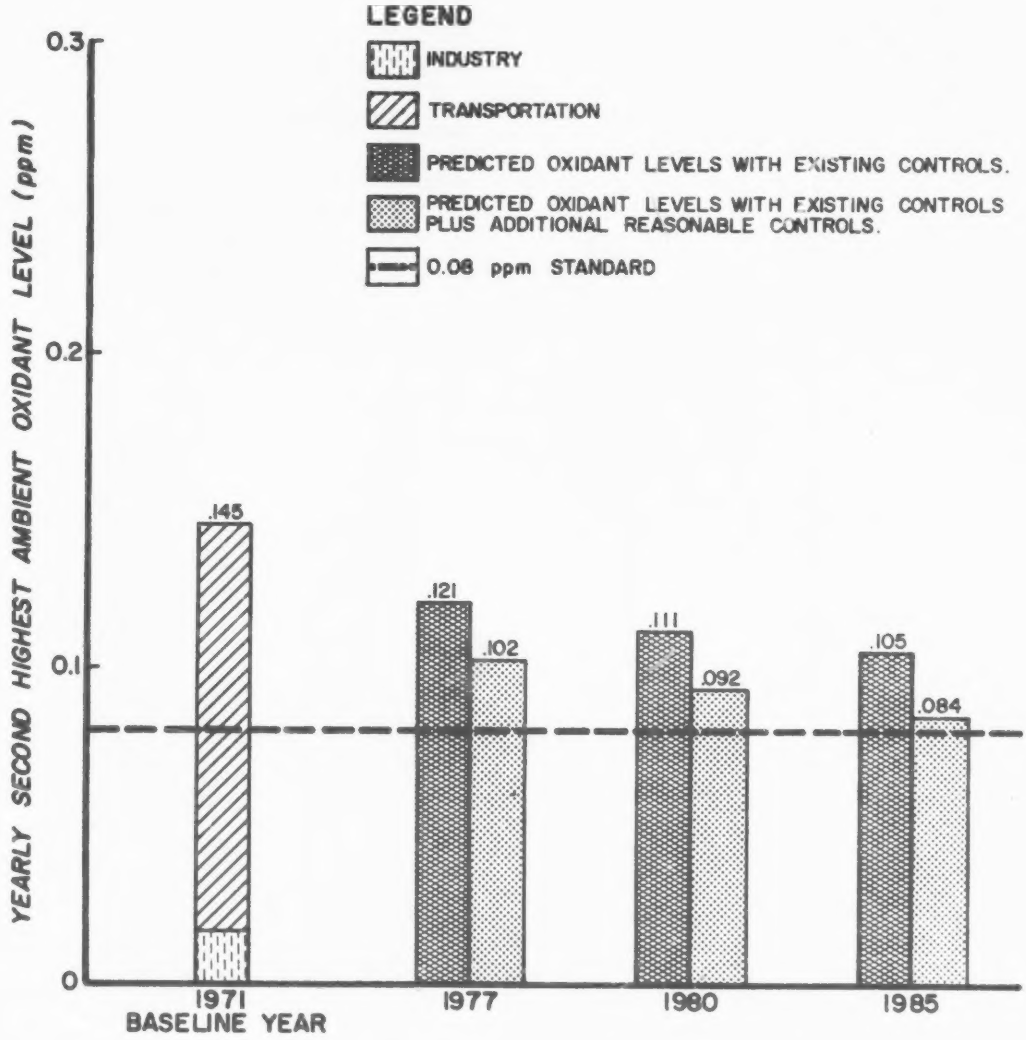

FIG. 7-7 OXIDANT LEVELS 1971 -1985 (SAN ANTONIO)

## Table 7-2A--Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Austin Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 3,426 | (20.5) | 4,923 | (29.6) | 5,706 | (34.3) |
| Stationary Sources | | | | | | |
| Gasoline Marketing | | | | | | |
| Stage I | 410 | (2.5) | 452 | (2.7) | 529 | (3.2) |
| Stage II | 483 | (2.9) | 532 | (3.2) | 623 | (3.7) |
| Crude Oil Storage Control | -- | -- | -- | -- | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| Mobile Sources | | | | | | |
| LDV Inspection/ Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 4,319 | (26.6) | 5,907 | (35.4) | 6,858 | (41.2) |
| Deficit | 4,010 | (24.0) | 2,422 | (14.6) | 1,471 | ( 8.8) |

Austin Area Counties: Travis and Hays

The requirement for gasoline marketing vapor recovery was recommended because this was the only additional stationary source control available in Austin and since this control provided more reductions than any of the other possible measures. This control is considered by EPA to be one of the more cost-effective ways of providing hydrocarbon emission reductions needed beyond those provided by the existing stationary and mobile source controls. Vapor recovery for gasoline marketing operations is in general being adopted nation-wide in areas with oxidant problems. EPA will be proposing these regulations for all areas in the State of Texas needing additional hydrocarbon reductions. However, the proposal for Stage II in Austin and in four other areas less severely polluted than Dallas and Houston will not be part of the interim measures proposed in the initial plan amendments. Stage II for Dallas and Houston will be proposed as part of the interim plan in the initial amendments. Stage II in Austin, Beaumont, Corpus Christi, El Paso, and San Antonio will be proposed in the second series of regulations which will complete the Long Range Plan. Table 7-2B shows the effects of the interim plan on emissions in Austin.

Two additional control measures, Inspection/Maintenance (I/M) and VMT reductions, were available to apply in these areas, but were not included as part of either the Long Range or Interim control strategy. I/M will definitely be needed in this area due to the large contribution of mobile sources to the hydrocarbon

## Table 7-2B--Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for Austin Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 3,426 | (20.5) | 4,923 | (29.6) | 5,706 | (34.3) |
| **Stationary Sources** | | | | | | |
| Gasoline Marketing | | | | | | |
| Stage I | 260 | (1.6) | 287 | (1.7) | 336 | (2.0) |
| Stage II | -- | -- | -- | -- | -- | -- |
| Crude Oil Storage Control | -- | -- | -- | -- | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| **Mobile Sources** | | | | | | |
| LDV Inspection/ Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 3,686 | (22.1) | 5,210 | (31.3) | 6,042 | (36.3) |
| Deficit | 4,643 | (27.9) | 3,119 | (18.7) | 2,287 | (13.7) |

Austin Area Counties: Travis and Hays

inventory. I/M would provide substantial reductions as well as ensuring that the reductions assumed from controls installed on new cars as part of the Federal Motor Vehicle Control Program are realized. However, until the State has developed an I/M program for the more severely polluted areas of Dallas/Fort Worth and Houston, I/M in Austin is not recommended as a part of the proposed control strategy. First priority should be given to developing the I/M program for the two most heavily polluted areas and then the strategy can be modified to include the other areas of the State, like Austin, where the automobile is causing the major portion of the oxidant problem. VMT reduction measures were not applied to Austin, since it is doubtful that a city of this size would accomplish significant VMT reductions without substantial social disruption.

### 7.2 Beaumont/Port Arthur Area Recommended Controls

The additional long range controls recommended for the Beaumont/Port Arthur area consist of extension of TACB Regulation V to one additional county, gasoline marketing vapor recovery, crude oil storage controls, and vapor recovery for ship and barge loading operations. The effects of the long range measures are presented in Table 7-3A. As shown in the table there will be further reductions required in 1977 and slightly more in 1985 to meet the standard. Substantial progress should be made toward attainment of the standard with the expected accomplishment of 69% reduction out of a required reduction of 75%.

## Table 7-3A--Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Beaumont-Port Arthur Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| **Present Controls Plus Growth** | 115,628 | (65.3) | 115,108 | (65.0) | 114,284 | (64.5) |
| **Stationary Sources** | | | | | | |
| Extension of Reg. V | 332 | (0.2) | 332 | (0.2) | 332 | (0.2) |
| Gasoline Marketing | | | | | | |
| Stage I | 341 | (0.2) | 425 | (0.2) | 496 | (0.3) |
| Stage II | 402 | (0.2) | 499 | (0.3) | 584 | (0.3) |
| Crude Oil Storage Control | 5,235 | (3.0) | 5,235 | (3.0) | 5,235 | (3.0) |
| Ship & Barge Vapor Recovery | 1,070 | (0.6) | 1,178 | (0.7) | 1,340 | (0.8) |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| **Mobile Sources** | | | | | | |
| LDV Inspection/ Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 123,008 | (69.5) | 122,777 | (69.4) | 122,271 | (69.2) |
| Deficit | 9,679 | (5.5) | 9,910 | (5.6) | 10,416 | (5.8) |

Beaumont-Port Arthur Area Counties: Hardin, Jefferson, and Orange

Since the primary source of hydrocarbon emissions in the Beaumont/Port Arther area is from stationary sources, all available stationary source controls have been recommended for this area. The mobile source controls, I/M and VMT reduction, have not been applied as part of either the Long Range or Interim Plan primarily due to the fact that mobile sources are not a major contributor to the oxidant problem in this area. In addition, it is doubtful that cities the size of Beaumont, Port Arthur, or Orange could accomplish significant VMT reductions without substantial social disruption. I/M may later be proposed for this area after the State has developed a system for Dallas/Fort Worth and Houston.

Stage II vapor recovery and ship and barge vapor recovery will not be part of the Interim Plan, but will be proposed with the second series of regulations in the Long Range Plan. Table 7-3B shows the effects of the interim plan on emissions in Beaumont/Port Arthur.

## 7.3 Corpus Christi Recommended Controls

The additional long range controls recommended for the Corpus Christi area consist of gasoline marketing vapor recovery, crude oil storage controls, and vapor recovery for ship and barge loading operations. The effects of these measures are presented in Table 7-4A. As shown in the table, there will remain substantial reductions required in 1977 as well as in 1985. Substantial progress will be made with the expected reductions of 40% out of a required reduction of 57%.

### Table 7-3B--Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for Beaumont-Port Arthur Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 115,628 | (65.3) | 115,108 | (65.0) | 114,284 | (64.5) |
| **Stationary Sources** | | | | | | |
| Extension of Reg. V | 332 | (0.2) | 332 | (0.2) | 332 | (0.2) |
| Gasoline Marketing | | | | | | |
| Stage I | 217 | (0.1) | 270 | (0.2) | 314 | (0.2) |
| Stage II | -- | -- | -- | -- | -- | -- |
| Crude Oil Storage Control | 5,235 | (3.0) | 5,235 | (3.0) | 5,235 | (3.0) |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| **Mobile Sources** | | | | | | |
| LDV Inspection/Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 121,412 | (68.6) | 120,945 | (68.4) | 120,165 | (67.9) |
| Deficit | 11,275 | (6.4) | 11,742 | (6.6) | 12,522 | (7.1) |

Beaumont-Port Arthur Area Counties: Hardin, Jefferson, and Orange

Table 7-4A--Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for Corpus Christi Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 28,860 | (36.6) | 30,251 | (38.4) | 27,483 | (34.8) |
| Stationary Sources | | | | | | |
| Extension of Reg. V | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | |
| Stage I | 307 | (0.4) | 339 | (0.4) | 397 | (0.5) |
| Stage II | 362 | (0.5) | 399 | (0.5) | 468 | (0.6) |
| Crude Oil Storage Control | 1,555 | (2.0) | 1,555 | (2.0) | 1,555 | (2.0) |
| Ship & Barge Vapor Recovery | 365 | (0.5) | 401 | (0.5) | 458 | (0.6) |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| Mobile Sources | | | | | | |
| LDV Inspection/ Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 31,449 | (39.9) | 32,945 | (41.7) | 30,361 | (38.5) |
| Deficit | 13,503 | (17.1) | 12,007 | (15.3) | 14,591 | (18.5) |

Corpus Christi Area Counties: Nueces and San Patricio

As was the case in Beaumont/Port Arthur, the main source of hydrocarbon emissions in Corpus Christi is from stationary sources. For this reason all available stationary source control measures have been applied. Mobile source controls have not been applied as part of either the Long Range or Interim Plan due to small reductions from this source and because significant VMT reductions measures would probably not be accomplished without social disruption. I/M may later be applied to the area after the State has developed such programs for Dallas/Fort Worth, Houston, and San Antonio.

Stage II vapor recovery and ship and barge vapor recovery will not be part of the Interim Plan, but will be proposed with the second series of regulations in the Long Range Plan. Table 7-4B shows the effects of the interim plan on emissions in Corpus Christi.

## 7.4 Dallas/Fort Worth Recommended Controls

The additional controls recommended for the Dallas/Fort Worth area consist of extending TACB Regulation V to one additional county, vapor recovery for gasoline marketing, crude oil storage controls, solvent controls for degreasing, I/M, and VMT reductions. The Long Range and Interim Plans for Dallas/Fort Worth are identical. The effects of these measures are presented in Table 7-5. Although significant reductions are obtained, the table shows that there will still be substantial reductions required even in 1985 in order to attain the standard.

Essentially all available controls have been applied to the Dallas/Fort Worth area due to the severity of the oxidant problem

### Table 7-4B--Reactive Hydrocarbon Emission Reductions under Recommended Interim Stategy for Corpus Christi Area

| | 1977 tons/yr | 1977 (%) | 1980 tons/yr | 1980 (%) | 1985 tons/yr | 1985 (%) |
|---|---|---|---|---|---|---|
| Present Controls Plus Growth | 28,860 | (36.6) | 30,251 | (38.4) | 27,483 | (34.8) |
| Stationary Sources | | | | | | |
| Extension of Reg. V | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | |
| Stage I | 195 | (0.2) | 215 | (0.3) | 252 | (0.3) |
| Stage II | -- | -- | -- | -- | -- | -- |
| Crude Oil Storage Control | 1,555 | (2.0) | 1,555 | (2.0) | 1,555 | (2.0) |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| Mobile Sources | | | | | | |
| LDV Inspection/ Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 30,610 | (38.8) | 32,021 | (40.6) | 29,290 | (37.1) |
| Deficit | 14,342 | (18.2) | 12,931 | (16.4) | 15,662 | (19.9) |

Corpus Christi Area Counties: Nueces and San Patricio

### Table 7-5--Reactive Hydrocarbon Emission Reductions under Recommended Long Range and Interim Strategy for Dallas/Ft. Worth Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 7,686 | (7.3) | 14,238 | (13.6) | 14,936 | (14.1) |
| Stationary Sources | | | | | | |
| Extension of Reg. V | 2,052 | (1.9) | 2,052 | (1.9) | 2,052 | (1.9) |
| Gasoline Marketing | | | | | | |
| Stage I | 2,828 | (2.7) | 3,134 | (3.0) | 3,725 | (3.6) |
| Stage II | 3,331 | (3.2) | 3,692 | (3.5) | 4,384 | (4.2) |
| Crude Oil Storage Control | 331 | (0.3) | 331 | (0.3) | 331 | (0.3) |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | 1,217 | (1.2) | 1,497 | (1.4) | 2,036 | (1.9) |
| Mobile Sources | | | | | | |
| LDV Inspection/ Maintenance | 2,659 | (2.5) | 1,990 | (1.9) | 1,556 | (1.5) |
| VMT Reductions (7%) | 3,906 | (3.7) | 3,273 | (3.1) | 2,845 | (2.7) |
| Total Reductions | 24,010 | (22.9) | 30,207 | (28.7) | 31,865 | (30.3) |
| Deficit | 36,012 | (34.1) | 29,815 | (28.3) | 28,157 | (26.7) |

Dallas-Ft. Worth Area Counties: Collin, Dallas, Denton, Ellis, Hood, Johnson, Kaufman, Parker, Rockwall, Tarrant, and Wise in the area. Due to the large deficit of reductions, even after application of the recommended controls, additional control measures beyond those recommended here will probably have to be developed and implemented in order to allow attainment of the oxidant standard.

## 7.5 El Paso Area Recommended Controls

The additional long range controls recommended for the El Paso area consist of vapor recovery for gasoline marketing, and crude oil storage controls. The effects of these measures are presented in Table 7-6A. The reductions shown are based on application of the regulation in El Paso only, but the calculated percent reductions are based on the total area emissions from both El Paso and Ciudad Juarez. As shown in the table, substantial reductions are obtained in emissions between 1977 and 1985, but there will remain further reductions required in 1985 to allow standard attainment. It should be noted that the projected percent reductions for El Paso/Juarez are probably the most uncertain of all seven Texas areas evaluated due to the rough approximation made of Ciudad Juarez emissions. A more detailed inventory for Ciudad Juarez emissions could result in significant changes in the expected reductions, particularly in 1980 and 1985.

Although the crude oil storage control regulation was applied to the El Paso area, to be consistent with the strategies for the rest of the State, no reductions were credited to this regulation because the TACB inventory shows all sources in this area to be already controlled. Gasoline marketing vapor recovery was applied

Table 7-6A--Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for El Paso Area (Juarez Included)

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 4,335 | (13.2) | 7,419 | (22.6) | 9,759 | (29.6) |
| Stationary Sources | | | | | | |
| Extension of Reg. V | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | |
| Stage I | 313 | (0.9) | 347 | (1.0) | 412 | (1.2) |
| Stage II | 368 | (2.3) | 408 | (2.5) | 485 | (3.0) |
| Crude Oil Storage Control | -- | -- | -- | -- | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| Mobile Sources | | | | | | |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 5,016 | (15.2) | 8,174 | (24.7) | 10,656 | (32.2) |
| Deficit | 7,529 | (22.8) | 4,371 | (13.3) | 1,889 | (5.8) |

El Paso Area (Juarez included) County: El Paso because this is the only other available stationary source control in El Paso, the control provides more reductions than any of the other possible measures, and the control is being applied statewide in areas with oxidant problems. However, the proposal for Stage II vapor recovery will not be part of the interim measures proposed in the initial plan amendments, but will be proposed with the second series of regulations in the Long Range Plan. Table 7-6B shows the effects of the interim plan on emissions in El Paso.

Two additional control measures, I/M and VMT reductions were considered available to apply in this area, but were not included as part of the control strategy. I/M is definitely needed in this area due to the large contribution of mobile sources and would provide significant hydrocarbon as well as carbon monoxide reductions. However, until the State has developed an I/M program for the more severely polluted areas of Dallas/Fort Worth and Houston, I/M is not recommended to be apart of El Paso's control strategy. First priority should be given to the heavily polluted areas and then the strategy modified to include other areas of the State like El Paso with less severe problems. VMT reduction measures were similarly not applied to El Paso nor in Corpus Christi, Beaumont, and Austin since it is doubtful whether significant reductions could be accomplished without substantial social disruptions.

## 7.6 Houston/Galveston Recommended Controls

The additional controls recommended for the Houston/Galveston area consist of gasoline marketing vapor recovery, crude oil storage controls, ship and barge vapor recovery, controls for

## Table 7-6B--Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for El Paso Area (Juarez Included)

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 4,335 | (13.2) | 7,419 | (22.6) | 9,759 | (29.6) |
| Stationary Sources | | | | | | |
| Gasoline Marketing | | | | | | |
| Stage I | 198 | (0.6) | 220 | (0.7) | 261 | (0.8) |
| Stage II | -- | -- | -- | -- | -- | -- |
| Crude Oil Storage Control | -- | -- | -- | -- | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | -- | -- | -- | -- | -- | -- |
| Mobile Sources | | | | | | |
| VMT Reductions | -- | -- | -- | -- | -- | -- |
| Total Reductions | 4,533 | (13.7) | 7,639 | (23.1) | 10,020 | (30.4) |
| Deficit | 8,012 | (24.3) | 4,906 | (14.9) | 2,525 | (7.6) |

El Paso Area (Juarez included) County: El Paso solvent degreasing, inspection/maintenance, and VMT reductions. The Long Range and Interim Plans for Houston are identical. The effects of these controls are presented in Table 7-7. Although significant reductions will be obtained, the table shows that there will still be substantial reductions required in order to attain the standard.

Essentially all reasonably available controls have been applied to the Houston/Galveston area due to the severity of the oxidant problem there. Due to the large deficit of reductions, even after applications of the recommended controls, additional controls beyond those recommended here will probably have to be developed and implemented in order to allow attainment of the oxidant standard.

## 7.7 San Antonio Area Recommended Controls

The additional long range controls recommended for the San Antonio area consist of gasoline marketing vapor recovery, solvent control for degreasing, inspection maintenance, and VMT reductions. The effects of these controls are presented in Table 7-8A. As shown in the table there will remain further reductions required to meet the standard even in 1985, but most of the required 45% reduction will be accomplished.

Stage II vapor recovery and inspection maintenance will not be part of the Interim Plan, but will be proposed with the second series of regulations in the Long Range Plan. Table 7-8B shows the effects of the interim plan on emissions in San Antonio.

### Table 7-7--Reactive Hydrocarbon Emission Reduction under Recommended Long Range and Interim Strategy for Houston-Galveston Area

| | 1977 tons/yr | (%) | 1980 tons/yr | (%) | 1985 tons/yr | (%) |
|---|---|---|---|---|---|---|
| Present Controls Plus Growth | 81,571 | (26.8) | 78,536 | (25.8) | 61,427 | (20.2) |
| **Stationary Sources** | | | | | | |
| Extension of Reg. V | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | |
| Stage I | 2,551 | (0.8) | 2,810 | (0.9) | 3,286 | (1.1) |
| Phase II | 3,003 | (1.0) | 3,309 | (1.1) | 3,866 | (1.3) |
| Crude Oil Storage Control | 12,292 | (4.0) | 12,292 | (4.0) | 12,292 | (4.0) |
| Ship & Barge Vapor Recovery | 1,724 | (0.6) | 1,895 | (0.6) | 2,158 | (0.7) |
| Solvent Control (degreasing) | 1,217 | (0.4) | 1,497 | (0.5) | 2,081 | (0.7) |
| **Mobile Sources** | | | | | | |
| LDV Inspection/ Maintenance | 2,636 | (0.9) | 1,918 | (0.6) | 1,397 | (0.5) |
| VMT Reductions (7%) | 3,872 | (1.3) | 3,155 | (1.1) | 2,553 | (0.8) |
| Total Reductions | 108,866 | (35.7) | 105,548 | (34.6) | 89,216 | (29.3) |
| Deficit | 92,101 | (30.3) | 95,419 | (31.4) | 112,751 | (36.7) |

Houston-Galveston Area Counties: Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Matagorda, Montgomery, and Waller

## Table 7-8A--Reactive Hydrocarbon Emission Reductions under Recommended Long Range Strategy for San Antonio Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 6,159 | (16.5) | 8,727 | (23.4) | 10,225 | (27.4) |
| Stationary Sources | | | | | | |
| Extension of Reg. V | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | |
| Stage I | 919 | (2.5) | 1,022 | (2.7) | 1,210 | (3.2) |
| Stage II | 1,082 | (2.9) | 1,202 | (3.2) | 1,425 | (3.8) |
| Crude Oil Storage Control | -- | -- | -- | -- | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | 932 | (2.3) | 1,127 | (3.0) | 1,510 | (4.0) |
| Mobile Sources | | | | | | |
| LDV Inspection/ Maintenance | 920 | (2.4) | 700 | (1.9) | 538 | (1.4) |
| VMT Reductions (7%) | 1,352 | (3.6) | 1,151 | (3.1) | 984 | (2.6) |
| Total Reductions | 11,364 | (30.4) | 13,929 | (37.3) | 15,892 | (42.5) |
| Deficit | 5,457 | (14.6) | 2,892 | (7.7) | 929 | (2.5) |

San Antonio Area Counties: Bexar, Comal and Guadalupe

## Table 7-8B--Reactive Hydrocarbon Emission Reductions under Recommended Interim Strategy for San Antonio Area

| | 1977 | | 1980 | | 1985 | |
|---|---|---|---|---|---|---|
| | tons/yr | (%) | tons/yr | (%) | tons/yr | (%) |
| Present Controls Plus Growth | 6,159 | (16.5) | 8,727 | (23.4) | 10,225 | (27.4) |
| Stationary Sources | | | | | | |
| Extension of Reg. V | -- | -- | -- | -- | -- | -- |
| Gasoline Marketing | | | | | | |
| Stage I | 919 | (2.5) | 1,022 | (2.7) | 1.210 | (3.2) |
| Stage II | -- | -- | -- | -- | -- | -- |
| Crude Oil Storage Control | -- | -- | -- | -- | -- | -- |
| Ship & Barge Vapor Recovery | -- | -- | -- | -- | -- | -- |
| Solvent Control (degreasing) | 932 | (2.3) | 1,127 | (3.0) | 1,510 | (4.0) |
| Mobile Sources | | | | | | |
| LDV Inspection/ Maintenance | -- | -- | -- | -- | -- | -- |
| VMT Reductions (7%) | 1,352 | (3.6) | 1,151 | (3.1) | 984 | (2.6) |
| Total Reductions | 9,362 | (25.0) | 12,027 | (32.2) | 13,929 | (37.3) |
| Deficit | 7,459 | (20.0) | 4,794 | (12.8) | 2,892 | (7.7) |

San Antonio Area Counties: Bexar, Comal and Guadalupe

All reasonably available controls have been applied to the area. Additional controls beyond those proposed here may have to be developed and implemented in order to ensure attainment of the oxidant standard. VMT reduction measures have been applied due to the large contribution to the oxidant problems caused by the autombile and due to the moderately severe oxidant problem being observed.

## 7.8 Cost Effectiveness of Recommended Control Measures

### 7.8.1 Introduction

Both positive and negative economic impacts can be expected from the proposed control measures in the Texas areas where they are to be applied. On the positive side there will be reductions in air pollution related health cost, reductions in automobile use costs to commuters, new jobs created in implementing the controls, and reduction in the consumption and evaporation of petroleum products. On the negative side these control measures will require expenditure of significant funds for installation and operation.

Estimates of capital and operating costs for most of the long range controls are presented in Table 7-9A. Table 7-9B summarizes the costs for the interim controls. Also included where applicable in Table 7-10 are annualized costs (direct operating expenses plus annual capital charges, minus any savings from recovered petroleum products) in order to better put in perspective what the costs for improving air quality will be on an annual and unit basis. Details of these cost estimates are discussed in the following paragraphs for each control measure.

## TABLE 7-9A Cost Estimates for Recommended Long Range Controls*

| CONTROL MEASURES | AREAS | | | | | | | TOTALS |
|---|---|---|---|---|---|---|---|---|
| | Austin | Beaumont-Port Arthur | Corpus Christi | Dallas-Fort Worth | El Paso | Houston Galveston | San Antonio | |
| Gasoline Marketing | | | | | | | | |
| Stage I | | | | | | | | |
| Capital | 1,374,600 | 1,313,600 | 828,300 | 10,463,400 | 1,257,700 | 7,526,100 | 2,645,100 | 25,409,000 |
| Operating | 11,900 | 11,400 | 7,200 | 90,500 | 10,900 | 65,100 | 22,900 | 219,800 |
| Stage II | | | | | | | | |
| Capital | 4,562,800 | 4,360,300 | 2,749,500 | 34,730,900 | 4,174,800 | 24,981,300 | 8,779,700 | 84,339,200 |
| Operating | 305,700 | 292,100 | 184,200 | 2,326,900 | 279,700 | 1,673,700 | 588,200 | 5,650,600 |
| Extension of Reg. V | | | | | | | | |
| Capital | | 350,000 | | 973,000 | | | | 1,323,000 |
| Operating | | 19,200 | | 53,300 | | | | 72,500 |
| Solvent Controls (Degreasing) | | | | | | | | |
| Capital | | | | 549,700 | | 549,700 | 419,100 | 1,518,400 |
| Operating | | | | --- | | --- | --- | --- |
| Ship and Barge | | | | | | | | |
| Capital | | 30,028,800 | 9,574,400 | | | 43,520,000 | | 83,123,200 |
| Operating | | 3,002,800 | 957,400 | | | 4,352,000 | | 8,312,300 |
| Crude Oil Storage | | | | | | | | |
| Capital | | 3,726,800 | 858,400 | 157,000 | | 5,726,400 | | 10,468,700 |
| Operating | | 37,300 | 8,600 | 1,600 | | 57,300 | | 104,700 |
| Inspection/Maintenance | | | | | | | | |
| Capital | | | | 4,685,900 | | 4,366,400 | 1,597,500 | 10,649,700 |
| Operating | | | | 17,830,000 | | 16,614,300 | 6,078,400 | 40,522,600 |
| VMT Reductions | | | | | | | | |
| Capital | | | | | | | | |
| Operating | NO COST DATA AVAILABLE AT THIS TIME | | | | | | | |

| | | |
|---|---|---|
| Grand Totals: | Capital | $216,831,200 |
| | Operating | $ 54,882,500 |

*Costs are in terms of 1975 dollars and no escalation due to inflation beyond 1975 has been included.

TABLE 7-9B Cost Estimates for Recommended Interim Control*

| Measure | Estimated Cost |
|---|---|
| Gasoline Marketing | |
| Stage I | |
| Capital | 23,401,200 |
| Operating | 202,500 |
| Stage II | |
| Capital | 59,712,200 |
| Operating | 4,000,600 |
| Extension of Reg. V | |
| Capital | 1,323,000 |
| Operating | 72,500 |
| Solvent Controls | |
| Capital | 1,518,400 |
| Operating | -- |
| Ship and Barge | |
| Capital | 43,520,000 |
| Operating | 4,352,000 |
| Crude Oil Storage | |
| Capital | 10,468,700 |
| Operating | 104,700 |
| Inspection/Maintenance | |
| Capital | 9,052,300 |
| Operating | 34,444,300 |
| VMT Reductions | |
| Capital | Not Available |
| Operating | |
| Totals: Capital | $148,995,800 |
| Operating | $ 43,176,600 |

*Costs are in terms of 1975 dollars and no escalation due to inflation beyond 1975 has been included

TABLE 7-10 Annualized Costs for Long Range Control Measures in Texas

| | CONTROL MEASURES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Stage I Vapor Recovery | Stage II Vapor Recovery | Extension of Regulation V | Solvent Controls (Degreasing) | Ship & Barge Vapor Recovery | Crude Oil Storage Control | Vehicle Inspection/ Maintenance | VMT Regulation | TOTAL |
| Net Annualized | $2,893,900 | $17,385,500 | $1,000 | $326,600 | $18,683,300 | -$552,300 (Savings) | $24,370,900 | Not Available | $63,108,900 |
| Unit Cost | 0.06¢ per gallon of gasoline pumped | 0.36¢ per gallon of gasoline pumped | -- | -- | 0.08¢ per gallon of gasoline produced | -- | $7.69 per Inspected | Not Available | |
| Cost per Ton of Pollutant Removed | $225 | $975 | $0 | $40 | $3,500 | $0 | $3,000 | Not Available | |

### 7.8.2 Cost for Gasoline Marketing Vapor Recovery (Stage I)

Capital costs per facility to install Stage I vapor recovery equipment vary from $1,000 to $3,000 with an average cost of about $2,000 (Ref. 7-1). There are approximately 19,000 gasoline dispensing facilities (Refs. 7-2 and 7-3) in the areas of concern and of these facilities the Stage I regulation would require about 57% (11,000) of the largest to install vapor recovery equipment. The capital cost for the 11,000 affected facilities will be $25,409,000. Also included in this cost is about $3.4 million to modify about 1,100 tank trucks for vapor recovery.

Assuming an annual capital charge of 16.3% (10 years at 10% interest) and an operating/maintenance (O/M) cost of $20/year/facility, the total annualized cost would be $2,893,900. On a cost per gallon pumped basis, the cost would be 0.06¢/gallon pumped at facilities with vapor recovery. On a cost per ton of total hydrocarbons reduced annually basis, the cost would be $225/ton. The annualized and unit figures all include a credit for the 4.2 million gallons of gasoline saved annually by Stage I vapor recovery.

### 7.8.3 Costs for Gasoline Marketing Vapor Recovery (Stage II)

Capital costs per facility to install Stage II vapor recovery equipment vary from $4,300 to $6,000 ($5,100 average) for intermediate size facilities expected to require a displacement system. For large throughput facilities requiring vacuum assist equipment the costs vary from $11,000 to $15,000 ($12,500 average). Based on station size information gathered by EPA primarily for Denver and

Boston (Ref. 7-3), 37% of the 19,000 facilities in the affected Texas areas are expected to require the displacement systems and 20% are expected to require the vacuum assist system. The remaining 43%, representing small facilities, will require no controls due to the higher cost buren they would have to bear if controlled. The capital cost for these affected facilities amounts to $84,339,200.

Assuming an annual capital charge of 16.3% (10 years at 10% interest) and an operation/maintenance (O/M) cost of 5% of the capital cost for displacement systems and 8% of the capital cost for vacuum assist systems, the total annualized cost would be $17,385,500. In terms of cost per gallon pumped at Stage II facilities the annualized cost would be about 0.36¢ per gallon. In terms of cost per ton reduced annually the cost would be $975/ton. The annualized cost and unit costs all include a credit for the 5.7 million gallons saved annually through Stage II vapor recovery.

The responsibility for the initial capital costs for both Stage I and Stage II vapor recovery equipment are expected to be split in accordance with the estimated breakdown of facility ownership shown in Table 7-11. From the table it is seen that about 45% of the initial capital costs will be borne by the oil companies and the remaining 55% by individual dealers, jobbers, or commercial users.

### 7.8.4 Costs for Extension of TACB Regulation V to Hardin and Tarrant Counties

## TABLE 7-11 Gasoline Dispensing Facility Ownership

| Type of Facility | Number Subject to Regulations | Oil Company Owned or Leased | Dealer or Comm. Facility Owned | Jobber Owned or Controlled |
|---|---|---|---|---|
| Service Station Retail | 7,300 | 4,964 | 219 | 2,117 |
| Non Service Station Retail | 1,550 | | | 1,550 |
| Commercial Users | 2,150 | | 2,150 | |
| | 11,000 | 4,964 (45%) | 2,369 (22%) | 3,667 (33%) |

Extension of Regulation V to Hardin and Tarrant Counties will affect primarily one petroleum refinery in each county. Based on testimony (Refs. 7-4 and 7-5) by these sources at TACB public hearings in April 1975 capital costs, O/M costs and annualizes costs have been computed. Based on the company statements the capital costs for complying with TACB Regulation V is $1,323,000. This cost is primarily for modification to storage tanks and loading racks at the refineries.

Assuming an annual capital charge of 16.3% (10 years at 10%) and an O/M cost of 1% of the capital for storage tank controls and 8% of the capital for loading rack controls, the total annualized costs would be $288,200. The net cost with a $287,300 credit for the 957,538 gallons/year of products recovered, is about $1,000 per year.

### 7.8.5 Cost for Solvent Controls (Degreasing)

Compliance with the degreasing regulation can be accomplished by either switching to a non or low reactive solvent or by vapor recovery systems. Since the solvent switch is by far the least expensive method of compliance, it is expected that the bulk of the degreasing sources will comply by this method. However, all sources may not be able to comply by switching solvents due to the nature of their degreasing operations and will have to use vapor recovery techniques.

In order to develop a cost estimate for this control it is assumed that 90% of the degreasing sources will comply by solvent switches and 10% by vapor recovery. Using the values developed by the TACB in reference 7-6 for solvent switching and an average vapor recovery (by adsorption) cost of $24,000 per degreaser (Ref. 7-7) the capital costs will be $1,518,400.

Assuming that the solvent switching costs will not be amortized (since they are a small one time expense), that the annual capital recovery costs for the vapor recovery equipment will be at 16.3% (10 years at 10%), and that the O/M costs for the vapor recovery equipment will be offset by the savings in solvent use (260,000 gal.), the annualized cost will be $326,600 for the three areas of concern. On a cost per ton of total hydrocarbon reduced basis the cost will be $38/ton.

### 7.8.6 Cost for Ship and Barge Vapor Recovery

At present there are no cost estimates for most of the facilities that will be required to install ship and barge vapor recovery equipment. One facility, Exxon Baytown Refinery, has made a preliminary capital estimate for compliance with the regulation of $12,000,000 for the refinery equipment and $4,000,000 for the ship/barge modifications (Ref. 7-8). In order to extrapolate this estimate to all facilities in the three areas of concern an assumption was made that the costs for facilities other than Exxon would be proportional to the estimated emissions from ship and barge loading operations developed in Section 5.3.2. Using this technique for the petroleum refineries in the Houston/Galveston area, the Beaumont/Port Arthur area, and the Corpus Christi area results in a total capital cost of $83,123,200.

Assuming an annual capital recovery cost of 13% (15 years at 10%), an annual O/M cost of 10% of the capital, and 30¢ credit per gallon for the 1.7 million gallons of gasoline recovered annually, the net annualized cost is $18,683,300 per year. In terms of cost per gallon shipped by ship or barge in Texas the cost is 0.25¢ gallon. In terms of cost per gallon of gasoline produced along the Texas Gulf Coast, the cost is 0.08¢/gallon. Also, in terms of cost per ton of total hydrocarbon reduced the cost is $3,500/ton.

### 7.8.7 Cost for Crude Oil Storage Controls

Based on the emission inventory worksheets provided to EPA by the TACB, there were 27 large-fixed roof crude oil storage tanks at the Exxon Baytown Refinery in 1972. The average new tank construction cost differential between large-fixed roof and floating roof tanks (55 to 600 m bbl) as taken from reference 7-9 is about $88,700. By adding 25% to cover the costs due to retrofit, the average per tank cost to retrofit the Exxon tanks becomes about $110,900. Using these values the total capital cost for the Exxon refinery would be $2,994,000. In order to extrapolate a cost for the oil companies it is assumed that the costs are proportional to the fixed roof crude oil storage tank emissions called out on the TACB worksheets in Appendix F. Using this method the capital costs for controlling large crude oil tanks at refineries in Houston, Beaumont, and Corpus Christi is $10,468,700.

Assuming an annual capital recovery cost of 13% (15 years at 10%), an annual O/M cost of 1% of the capital, and a 15¢ credit per gallon for the 13.5 million gallons recovered annually, the net value is a cost savings of $552,300.

### 7.8.8 Cost for Vehicle Inspection and Maintenance (I/M)

Cost estimates were made in reference 7-10 for implementation on I/M program as a part of the existing Texas Safety Inspection Program. Estimates were included for the expected increased inspection fee, repair costs, and savings from improved fuel economy. The estimates presented in reference 7-10 form the basis for the I/M costs presented in Table 7-9A but have been adjusted to apply only to the three Texas areas being recommended for the program. In addition the reference 7-10 estimates were adjusted to use a three year instead of a one year payback by inspection stations for the emission instruments and the gasoline mileage improvements have been increased from 1% overall to 1-1/2% (Ref. 7-11).

Using the adjusted estimates the total capital costs for I/M in the three areas will be $10,649,700. The operating costs (primarily vehicle repair costs) will be $40,522,600 per year. Taking credit for the 38.4 million gallons of gasoline saved and spreading the capital costs for instruments over three years, the net annual costs for I/M in Texas would be $24,376,900. In terms of cost/vehicle inspected the cost is $7.69/vehicle. In terms of costs per ton of pollutant removed the costs is about $3,000/Ton*.

### 7.8.9 Costs for VMT Reduction Measures

Until specific programs are outlined by cities and employers, cost estimates can not be made for this control.

*Note: The cost/ton are expected to be much lower than this value (by as much as a factor of two) when the effects of higher deterioration of cars with emission controls and of tampering are included. At present, however, there is not sufficent data to quantify these effects.

## References for Section 7.0

7- 1 Telephone conversation with E. J. Vincent, EPA Office of Air Quality Planning and Standards.

7- 2 Texas Department of Agriculture Weights and Measures Computer Printout (C157) of Retail Gasoline Pumps by County, dated 9/24/75.

7- 3 Arthur D. Little, Inc., Letter with Attachments dated September 4, 1975, which documents retail and non-retail gasoline outlet distributions for Denver and Boston.

7- 4 Testimony by Mr. E. Sager representing Winstein Refining Company, at the public hearings held by the Texas Air Control Board in Fort Worth on April 18, 1975.

7- 5 Testimony by Mr. Jack Dana, Executive Vice President of South Hampton Company, at the public hearings held by the Texas Air Control Board on April 18, 1975.

7- 6 Texas Air Control Board Report No. SP-3, Documentation for Cost Estimates for Implementing Controls Required by EPA, dated August 4, 1975.

7- 7 EPA Report - 45/2-74-006, Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, dated September 1974.

7- 8 Exxon Company, USA, letter dated September 12, 1975, from Mr. J. M. Johnson on the expected capital costs of ship and barge vapor recovery equipment.

7- 9 Process Plant Contruction Estimating Standards, Volume 4, Division 100, Published by Richardson Engineering Services, Inc., 1975.

7-10 Report by RADIAN Corporation, A Program for Implementation of Vehicle Inspection/Maintenance in Four Regions of Texas, dated August 19, 1975.

7-11 Telephone conversation on September 4, 1975 with Mr. H. Davis, EPA Ann Arbor.

# APPENDICES

There are 465 pages of appendices to this report and consist primarily of TACB data worksheets. Due to the number of pages and the fact they are most handwritten, the appendices have not been printed and published as a part of this document. However, copies of the appendices will be available for public inspection during normal business hours at the following locations:

Environmental Protection Agency
Region VI
1600 Patterson, Suite 1100
Dallas, Texas 75201

Environmental Protection Agency
Houston Facility
6608 Hornwood
Houston, Texas 77036

Environmental Protection Agency
Public Information Reference Unit
Room 2922, EPA Library
401 "M" Street S.W.
Washington, D.C. 20460